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Analysis of Gait Pattern and it's Relationship to Human Personality

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Abstract:

Gait pattern impressions are considered as evidence in the field of forensic science in terms of stature examination [based on comparison between known and unknown samples], in determining the point of entry and exit, the number of people involved in a particular crime, the type of footwear worn by the perpetrator, etc. The gait pattern is defined as a person's pattern of walking, which involves coordination of muscles and balance and results in the forward propelling of the body in a rhythm called stride. The analysis of gait pattern involves proper recording of the pattern [photographs] and its measurement, along with interpretation of the psychological test scales that were administered to the same person whose gait pattern has been recorded. The objective of this research work was to study the relevance of personality and its effect in terms of the gait pattern of a person.

Keywords: *Gait pattern analysis, Criminal profiling, Personality, DASS-21, Eysenck's Personality Inventory (EPI), Human gait pattern*

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Introduction

Gait pattern analysis is a technique for measuring and analysing a person's walking stride. It is employed in many different disciplines, including as forensics **(Nagwanshi, 2022),** sports science **(Gu *et al*., 2021; Zhang *et al*., 2020),** and medicine **(Rubino, 2000).** In the field of forensic science, gait pattern analysis is a technique that is implied in order to identify individuals **(Sarkar *et al*., 2005),** exclude suspects, and reconstruct crime scenes. Growing interest has been shown in the possibility of gait pattern analysis as a tool for determining personality characteristics in recent years **(Kuhnke *et al*., 2019)**.

Certain researches to support the relationship between personality and gait type. The Association between High Neuroticism-Low Extraversion and Dual-Task Performance during Walking While Talking in Non-demented Olde [Adults Brittany C. LeMonda, Jeannette R. Mahoney, Joe Verghese and Roee Holtzer] states that individuals with high extra-version levels tended to walk with a longer stride and a more vivacious gait, whereas individuals with high neuroticism levels tended to walk with a shorter stride and a more cautious pace. Gait disorders in adults and the elderly - A clinical guide [Walter Pirker, Regina Katzenschlager] states that those who are pleasant tend to walk more symmetrically. In this research the relevance of personality and its effect in terms of gait pattern of a person **(Destephe *et al*., 2013)**.

Factors such as age, heredity, disease, prior medical history (surgeries), the surface they are walking on, consumption of drugs (if used), and personality which can also affect a person's gait pattern. This study is done to ascertain the relationship of gait pattern with the personality of a human, along with considering all other factors mentioned above. The personality of the subject is assessed by administering psychological assessment tests, which are used as a tool in terms of analysing the personality and the present emotional state of the subject.

Review of Literature

The gait pattern can be used in terms of determining the personality of an individual based on their walk pattern. Numerous studies conducted by the author regarding the relevance of personality and its effect in terms of the gait pattern of a person are described herein.

- **Relationship between personality and gait: predicting personality with gait feature [Jiumo Sun; Peiqi Wu; Yali Shen; Zhixin Yang],** it has been inferred that gait data can be used to provide insights into a person's personality, such as their level of neuroticism, extra-version, and psychoticism. This information can be used to improve our understanding of human behavior and to develop new ways to assess personality.

- **Emotional Gait Generation Method based on Emotion Mental Model - Preliminary experiment with Happiness and Sadness [Matthieu Destephe; Kenji Hashimoto; Atsuo Tak],** were the inference of this research states that Emotional gaits could be used to convey a variety of emotional messages, such as happiness, sadness, anger, and fear.

- **Are we Revealing Hidden Aspects of our Personality When we Walk? [Brittany Blaskovits, Craig Bennel],** provides important insights into the victim selection process and how body language can be used to detect vulnerability. This information can be used to develop strategies to prevent victimization.

- **Self-esteem recognition based on gait pattern using Kinect [Bingli Sun, Zhan Zhang, Xingyun Liu, Bin Hu, Tingshao Zhu],** the aim of the research was to ascertain whether is it possible to recognize the self-esteem based on using the Kinect. Outcome of this research states that the Kinect sensor could be used to measure self-esteem in a variety of settings, including clinical settings, schools, and workplaces. The study's findings have the potential to improve the assessment and treatment of low self-esteem.

- **JAMA Neurology Clinical Challenge Personality Change and Gait Dysfunction – [Lawrence S. Honig, MD, PhD];** the aim was of the research was to ascertain whether is the any variation in terms of gait pattern of an individual in a case where that person affected by progressive supranuclear palsy (PSP)Outcome of this research stated that respective patient possess symptoms included gait and balance problems, personality changes, cognitive decline, and motor dysfunction.

- **Recognition of Affect Based on Gait Patterns – [Michelle Karg, Kolja Kühnlenz, and Martin Buss]** The study's findings imply that there are noticeable changes in gait patterns when people feel distinct emotions. The study investigates the feasibility of utilizing gait patterns to distinguish emotional states, demonstrating that emotions may impact how people walk.

Aim of Research

Determining the level of relevance in between the personality and present emotional state of a person via applying Eysenck personality inventory and DASS-21 and comparing the results along with the measurements of gait pattern to ascertain whether there is any sort of influence / variations in the gait patterns of a person [Multivariate analysis].

Objectives

- The primary objective of this study is to verify whether there is any relevance in terms of personality and gait pattern **(Janssen *et al*., 2008)**.
- In this research, factors such as personality (whether they are introverts, extroverts, or ambiverts), the neuroticism level of the subjects, and their present mental state are assessed and interpreted.

Methodology

Primary data and secondary data were used in this research. A total of 35 subjects, both male and female, took part and were assigned to provide their gait pattern and administer the psychological assessments such as the Eysenck personality inventory and Depression, Anxiety and Stress Scale - 21 items (DASS-21) respectively. The data was collected using google forms.

The gait pattern was recorded using thumb impression ink [in order to obtain a clear footprint], which was spread uniformly on a glass surface using a roller. The subjects were first made to place their feet on the glass surface, which bears the thumb impression ink, and then they were expected to walk on the tiled surface [in order to form an inked gait pattern]. All the subjects were made to walk on the same surface [tiles] in order to prevent any variations in the gait pattern caused by the differences in the surface. Then the obtained gait patterns were recorded via photography [long range, mid-range and close range]. In terms of identifying or detecting a person's personality and present emotional state, after the respective subject / person whose gait pattern was been obtained prior will be subjected to psychological scaling tests: - **Eysenck personality inventory and DASS-21 respectively.**

- The gait pattern samples were measured using a measuring tape [20 feet length] and the measurements such as **total stride length [3 strides], stride length [single stride] and single foot measurement** of each gait patters are taken and recorded **(Troje, 2002)**.
- Another form of recording the gait pattern was done via photography based on the measurements mentioned above.

Figure: 1 *Figure: 2* *Figure: 3*

Figure No. 1, 2 and 3 shows the gait patterns that were provided by the subject and recorded using thumb impression ink and photography.

Figure No. 4: It shows the ink which is used for recording foot print - gait pattern

Figure No. 5: It shows the glass slab used for spreading the ink.

Google forms of eysenck personality inventory and depression, anxiety and stress scale - 21 items (dass-21): -

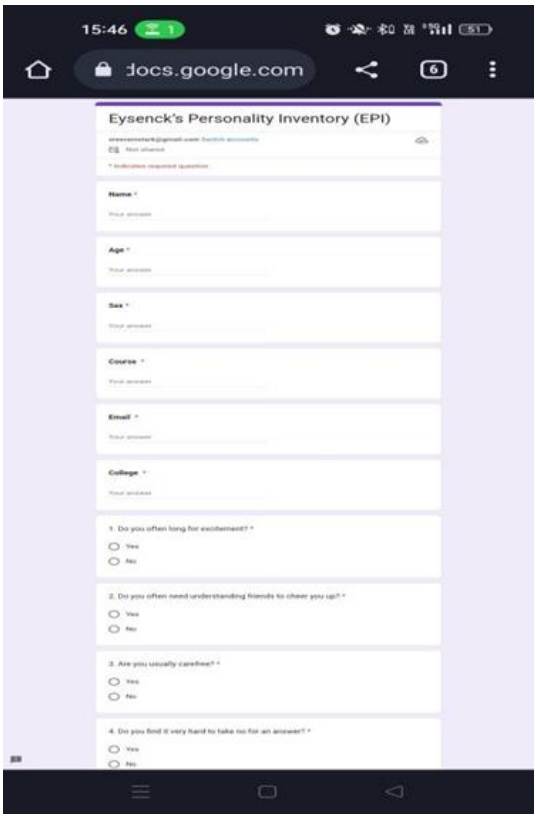

Figure No. 6: It shows the Eysenck personality inventory administered in terms of assessing the personality of a person via google forms.

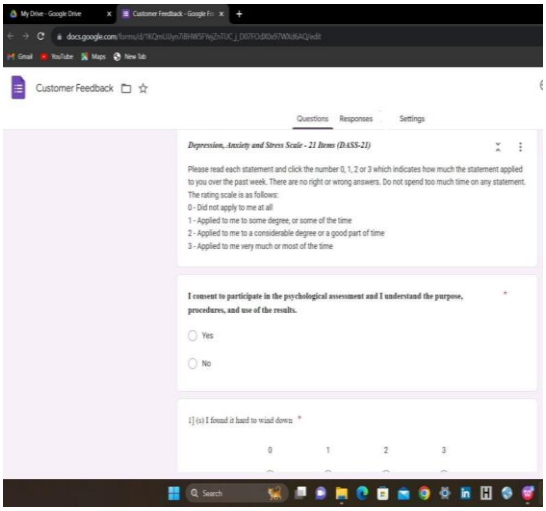

Figure No. 7: It shows the Depression, Anxiety and Stress Scale - 21 items (DASS-21) administered in terms of assessing the emotional state of a person via google forms.

Result and Discussion

Multivariate analysis is used to predict the relevance in terms of personality and gait pattern **(Karg *et al*., 2010)**. In order to ascertain the objectives of this research, the measurements of the gait pattern were taken and compared with the results of personality assessment tests in order to verify whether there is any variation in terms of measurements with relevance to the different personalities **(Satchell *et al*., 2017)**. exhibited by the respective subjects [based on the mean values of the gait pattern measurements and the results of the personality assessment tests].

Scoring Key for the Psychological Assesment: -

Depression, Anxiety and Stress Scale - 21 Items (DASS-21)

The rating scale is as follows:

0 - did not apply to me at all.

1 - Applied to me to some degree, or some of the time

2 - Applied to me to a considerable degree or a good part of time

3 - It applies to me very much, or most of the time.

Meaning	Depression	Anxiety	Stress
Normal	0-9	0-7	0-14
Mild	10-13	8-9	15-18
Moderate	14-20	10-14	19-25
Severe	21-27	15-19	26-33
Extremely severe	28+	20+	34+

Figure No. 8: Shows the scoring key for Depression, Anxiety and Stress Scale - 21 Items (DASS-21)

Eysenck Personality Inventory

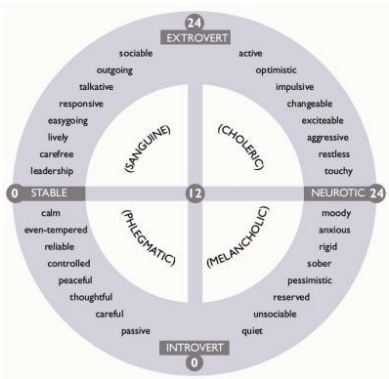

Figure No. 9

Eysenck's Personality Inventory (EPI) (Extroversion/Introversion)

When you fill out Eysenck's Personality Inventory (EPI) you get three scores.

- The 'lie score' is out of 9. It measures how **socially desirable** you are trying to be in your answers. Those who score 5 or more on this scale are probably trying to make themselves look good and are not being totally honest in their responses.
- The 'E score' is out of 24 and measures how much of an **extrovert** you are.
- The 'N score' is out of 24 and measures how **neurotic** you are.

Figure No. 10

N Score Table for Form A

Question:		Question:	
2	Yes	31	Yes
4	Yes	33	Yes
7	Yes	35	Yes
9	Yes	38	Yes
11	Yes	40	Yes
14	Yes	43	Yes
16	Yes	45	Yes
19	Yes	47	Yes
21	Yes	50	Yes
23	Yes	52	Yes
26	Yes	55	Yes
28	Yes	57	Yes

Figure No. 11

Lie Scale

Question	
6	Yes
12	No
18	No
24	Yes
30	No
36	Yes
42	No
48	No
54	No

Figure No. 12

E Score Table for Form A

Question:		Question:	
1	Yes	29	No
3	Yes	32	No
5	No	34	No
8	Yes	37	No
10	Yes	39	Yes
13	Yes	41	No
15	No	44	Yes
17	Yes	46	Yes
20	No	49	Yes
22	Yes	51	No
25	Yes	53	Yes
27	Yes	56	Yes

Figure No. 13

Figures: 9,10,11,12,13 – They Show the scoring keys and scales for Eysenck Personality Inventory

Measurements Of Each Gait Patterns Admitted [Stride Measurement, Stride Length And Foot Measurement]

Table 1: Showing the recording of the measurements each gait patterns admitted [stride measurement, stride length and foot measurement]

SI No.	NAME	STRIDE MEASUREMENT	STRIDE LENGTH	FOOT MEASUREMENT
	Maheshwari			
1	M	12.75ft	3.625ft	22cm
2	Suhaib K	16.55ft	4.5ft	27cm
3	Zayyan	13.6ft	3.875ft	25.5cm
4	Amulya	17.2ft	4.7ft	23.8cm
5	Ishwarya	19.3ft	4.98ft	23cm
6	Haripriya	17.17ft	4.10ft	24.3cm
7	Gowtham	16.6ft	4.45ft	25cm
8	Disha	19ft	5.15ft	23.8cm
9	Archana	18.8ft	5ft	22.4cm
10	Amudha	15.65ft	4.2ft	23cm
11	Tejas	14.7ft	4.11ft	23.5cm
12	Arun	20.2ft	5.6ft	25.5cm
13	Shreeram	17.11ft	5ft	26.5cm
14	Amjath	16.8ft	4.5ft	23cm
15	Lakshmi	13ft	3.43ft	22.4cm
16	Manjeera	16.7ft	4.5ft	24.2cm
17	Rosegiya	16ft	4.34ft	21.5cm
18	Midhun	16.25ft	4.726ft	24.5cm
19	Astha	16.10ft	4.7ft	22cm
20	Meghana	19.1ft	5.06ft	23.5cm
21	Ankit	15.1ft	4.5ft	25cm
22	Yuvika	15.10ft	4.1ft	22.3cm
23	Suma	16.8ft	4.5ft	24 cm
24	Aditya	15.1ft	4.6ft	25 cm
25	Krishna	18.8ft	4.11ft	25.3cm
26	Jayalakshmi	11.12ft	3.4ft	23cm
27	Sathya	18.2ft	4.7ft	23cm
28	Harika	16.10ft	4.4ft	24 cm
29	Abarna	17.7ft	4.85ft	22.5cm
30	Estherrani	13.47ft	4.4ft	21cm
31	Sowmeia	17.67ft	4.10ft	23.5cm
32	Aarthi	13.47ft	4.5ft	21.5cm
33	Karthika	18.1ft	4.10ft	23.5cm
34	Akina	14.9ft	3.65ft	24 cm
35	Ameya	13.4ft	3.4ft	22cm

Interpretation Of The Relevance In Between The Measurements Of Gait Pattern Samples And Results Psychology Assesments

1. Interpretation of Eysenck Personality Inventory's result

Table No. 2: Showing the types of personality in terms of the assessment and the percentage of subjects [out of 35] being in the respective personality category

SUBJECTS [POPULATION] - 35 n. o	OUT OF 35 SUBJECTS, % OF BEING
INTROVERT	22.86% [18]
AMBIVERT	54.29% [09]
EXTROVERT	22.86% [09]

2. Interpretation of Depression, Anxiety and Stress Scale - 21 Items (DASS-21) results

Table No. 3: Showing the measurement of different emotional states in terms of the assessment and the percentage of subjects [out of 35] being in the respective personality category

SUBJECTS [POPULATION] - 35 n. o	OUT OF 35 SUBJECTS, % OF BEING
DEPRESSION	MILD [03] - 8.57% MODERATE [11] - 31.43% NORMAL [19] - 54.29% SEVERE [01] - 2.86% EXTREMELY SEVERE [01] - 2.86%
ANXIETY	MILD [12] - 34.29% MODERATE [01] - 2.86% NORMAL [22] - 62.86%
STRESS	MILD [01] - 2.86% MODERATE [01] - 2.86% NORMAL [33] - 94.29%

3. Interpretation of gait pattern measurements

Table No. 4: Showing the different measurements of the gait pattern samples and the means values of the measurements carried over in measuring the gait patterns

SAMPLE SIZE - TOTAL 35 n. o	MEAN VALUE
TOTAL STRIDE LENGTH [3 STRIDES]	16.230 Feet
STRIDE LENGTH	4.401 Feet
SINGLE FOOT MEASUREMENT	24.36 cm

Interpreation of The Relevance in Between the Measurements of Gait Pattern Samples and Results of Eysenck Personality Inventory

1. Interpretation of gait pattern measurements of subjects [Ambiverts]

Table No. 5: Showing mean values— interpretation of gait pattern measurements of subjects who are ambiverts in terms of their personalities

AMBIVERT	MEAN VALUE
TOTAL STRIDE LENGTH [3 STRIDES]	16.498 Feet
STRIDE LENGTH	4.5 Feet
SINGLE FOOT MEASUREMENT	25.1 cm

2. Interpretation of gait pattern measurements of subjects [Introverts]

Table No. 6: Showing mean values— interpretation of gait pattern measurements of subjects who are introverts in terms of their personalities

INTROVERT	MEAN VALUE
TOTAL STRIDE LENGTH [3 STRIDES]	16.275 Feet
STRIDE LENGTH	4.396 Feet
SINGLE FOOT MEASUREMENT	23.88 cm

3. Interpretation of gait pattern measurements of subjects [Extroverts]

Table No. 7: Showing mean values— interpretation of gait pattern measurements of subjects who are extroverts in terms of their personalities

EXTROVERT	MEAN VALUE
TOTAL STRIDE LENGTH [3 STRIDES]	15.9275 Feet
STRIDE LENGTH	4.175 Feet
SINGLE FOOT MEASUREMENT	22.75 cm

4. Interpretation of gait pattern measurements of subjects [Neurotic]

Table No. 8: Showing mean values— interpretation of gait pattern measurements of subjects who are neurotic in terms of their personalities

NEUROTIC	MEAN VALUE
TOTAL STRIDE LENGTH [3 STRIDES]	16.485 Feet
STRIDE LENGTH	4.292 Feet
SINGLE FOOT MEASUREMENT	22.84 cm

5. Interpretation of gait pattern measurements of subjects [non-Neurotic]

Table No. 9: Showing mean values— interpretation of gait pattern measurements of subjects who are non - neurotic in terms of their personalities

NON - NEUROTIC	MEAN VALUE
TOTAL STRIDE LENGTH [3 STRIDES]	16.061 Feet
STRIDE LENGTH	4.475 Feet
SINGLE FOOT MEASUREMENT	25.387 cm

The outcomes and results from this particular research stated that there is no relevance in terms of personality to that of gait pattern due to the comparison done between the mean values of measurements of gait pattern with respect to the personality and emotional state of a person, which shows variation that is considerably lesser [ranging from 2 - 8 cm approx.] **(Sepas-Moghaddam and Etemad, 2023)** where these types of variations are seen commonly in cases of successive strides [or] due to abnormal walking patterns, so that gait pattern measurements cannot be used as a ddetermining factor in terms of ascertaining [or] interpreting the personality of a person or an emotional state of a person **(Sun *et al*., 2017; Sun *et al*., 2018)**.

- Only three yardsticks in terms of measuring gait pattern are taken into consideration.
- In the case of the DASS-21 scale, 5% of the total population of subjects gave false responses, which led to a slight variation in terms of the interpretation of the results as a whole.

Conclusion

However, there are many predominant studies stating that there is certain relevance between personality and gait pattern, but when it comes to standardized measurements of gait patterns along with the administration of psychological assessments [in this particular research], the outcomes of this research state that the variations in terms of measurements [mean values] are considerably less when compared with the interpretations obtained as a result of the administered personality test. By inferring the outcomes of the research, we can come to a conclusion stating that there is no relevance in terms of gait pattern and the personality of a person.

Limitations

- With a limited subject size of 35, research is carried out over a large scale of population, resulting in considerable variations in terms of outcomes [relevance between personality and gait pattern can be seen].
- Interpretations of results are not done based on the gender of individuals

Scope For Further Enhancement

This study opens the scope for further researches such as studying the: -

- Relevance between gait pattern and the psychological state of a person. [based on qualitative and quantitative research]
- Variation seen in the gait patterns with respect to the mental abnormalities or disorders found in an individual.
- Variation is seen in terms of gait pattern and its relevance in terms of drug abuse and the habits of an individual etc.

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