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The Relationship Between Critical Flicker Fusion Frequency (CFFF) and Temperamental Characteristics

Anna Łuczak
Andrzej Sobolewski

Department of Ergonomics, Central Institute for Labour Protection, Warsaw, Poland

The analysis in this paper was based on data obtained from 80 male participants, aged 29-65. Critical Flicker Fusion Frequency (CFFF) was measured using the Flicker Test. The Formal Characteristics of Behaviour—Temperament Inventory (FCB-TI) by Strelau and Zawadzki (1993) was used for temperamental characteristics. The results of statistical analysis did not confirm a hypothesis about the correlation between CFFF level and 3 temperamental characteristics. There were no immediate relationships among those variables. Correlation was observed when the CFFF coefficient of variance, instead of average CFFF values, was taken into account, especially in the case of a division into 2 groups of participants, "reckless" and "unsure." It could be interesting to check in the future a hypothesis about the stability of selected types of reactions.

CFFF temperament

1. INTRODUCTION

Critical Flicker Fusion Frequency (CFFF) arouses the interest of researchers in different areas like medicine, physiology, and psychology. In medicine and physiology, CFFF is treated as an indicator of physiological changes in the human after the use of drugs or alcohol (Jansen, de Gier, & Slanger, 1985, 1986; Weber, Jeremini, & Grandjean, 1975).

Correspondence and requests for reprints should be sent to Anna Łuczak, Central Institute for Labour Protection, ul. Czerniakowska 16, 00-701 Warszawa, Poland. E-mail: <anluc@ciop.pl>.

First of all, CFFF is accepted and used as an indicator of the cortex arousal level and as an indicator of physical human fatigue and mental workload. The results of physiological and neuropsychological experiments indicate that the retina (Iwasaki, Kurimoto, & Noro, 1989; Walker, as cited in Marek, 1987) and the cortex (Goldman, Lodge, Hammer, Semmes, & Mishain, 1986), especially in the left hemisphere (Marek, 1987), are responsible for light flickering perception.

Many significant correlations between the CFFF level and environmental factors have been proved. Those factors are the time of day (Matsumoto, Sasagawa, & Kawamori, 1978; Ogiński, Koźlakowska-Świgoń, Pokorski, & Iskra-Golec, 1981), the colour of the visual stimulus in the Flicker Test (a method of measuring the CFFF level; Misawa & Shigeta, 1986), atmospheric pressure (Seki & Hugon, 1977), and work monotony (Ikeda, Sato, & Tamura, 1989).

Experiment results also demonstrate the relationships between the CFFF level and individual human attributes like age (Curran, Hindmarch, Wattis, & Shillingford, 1990; Ishibashi, 1982), intelligence (Atwal et al., 1988), sex (Amir & Ali, 1989), and job experience (Osaki, Kikuchi, & Ogata, 1976). Especially interesting is CFFF's dependence on the subjective feeling of fatigue. It appears that the course of CFFF diurnal changes has the form of a reverse U: the CFFF level increases from the beginning of the work day to the moment when the human feels fatigue. From this moment CFFF decreases (Rosner, 1982). It has also been reported that personality factors, sociability and impulsiveness, are related to changes in the CFFF level (Corr, Pickering, & Gray, 1995).

It seems that this is not a complete list of factors connected with the CFFF level and with the character of its changes. It has been assumed that temperament—as an individual attribute—could influence the characteristic of CFFF changes.

Already in the Pavlov School, CFFF appeared as an indicator of one of the attributes of the nervous system, lability, which manifests itself in the rapidity of the appearance and disappearance of nervous processes (Borisowa, Szwarc, as cited in Strelau, 1985). The greater the nervous system liability, the higher the CFFF level.

The nervous system and its characteristic are the bases of temperament: one of the main individual attributes. Strelau described temperament in the following way: It "refers to basic, relatively stable personality traits which apply mainly to the formal aspects of reactions and behaviour (energetic and temporal **characteristics).** These traits are present since early childhood

and they occur to man and animals. Being primarily determined by inborn physiological mechanisms, temperament is subject to changes caused by maturation and by some environmental factors" (Strelau & Zawadzki, 1993, p. 117).

The Strelau Temperament Theory (Strelau & Zawadzki, 1993) distinguishes six temperamental traits:

- Briskness—the tendency to react quickly, to keep a high tempo of performing activities, and to shift easily in response to changes in the surroundings from one behaviour to another);
- Perseverance—the tendency to continue and to repeat behaviour after cessation of stimuli (situations) evoking this behaviour;
- Sensory sensitivity—the ability to react to sensory stimuli of low stimulative value;
- Emotional reactivity—the tendency to react intensively to emotion-generating stimuli, expressed in high emotional sensitivity and in low emotional endurance;
- Activity—the tendency to undertake behaviour of high stimulative value or to supply by means of behaviour the most favourable stimulation from the surrounding;
- Endurance—the ability to tolerate strong stimulation; resistance to fatigue and pain.

Taking into account that the nervous system attributes determine temperamental characters, it seems to be reasonable to assume that there is a relationship between the CFFF level and temperament attributes. This assumption especially concerns three temperamental attributes:

- Activity—CFFF, as an indicator of cortex activity (Goldman et al. 1986; Osaki, as cited in Marek, 1987), may depend on human physical and mental activity;
- Emotional reactivity—according to the Strelau Individual Differences Theory (Strelau, 1985), reactivity regulates an individual stimulation level, the activity level as a consequence, and probably indirectly also the CFFF level;
- Briskness—Activity and Emotional reactivity correlate with Briskness (Strelau & Zawadzki, 1993).

Taking into account these premises, the following hypothesis was posed: CFFF level correlates with three temperamental characteristics: Activity, Emotional reactivity, and Briskness: High CFFF level is characteristic for high Activity, Emotional reactivity, and Briskness.

This paper presents the results of a study that checked that hypothesis.

The problem is interesting from both the theoretical and practical points of view: Learning about factors connected with CFFF widens the knowledge about the CFFF characteristics. It also allows to control their influence and to arrange experiments with CFFF with regard to the fact that these factors could be significant moderators in the analysed relations.

2. METHOD

2.1. Participants

Eighty participants took part in the study. They were male middle managers aged 29-65, from five different enterprises.

2.2. Temperamental Characteristic

The Formal Characteristics of Behaviour—Temperament Inventory (FCB-TI) by Strelau and Zawadzki (1993) was used to describe the individual temperamental characteristic. This Inventory contains six scales: Briskness, Perseverance, Sensory sensitivity, Emotional reactivity, Endurance, and Activity. A point score (0-20) on each scale was an indicator of the level of temperamental characteristics. The psychometric characteristic of the FCB-TI is satisfactory.

2.3. Critical Flicker Fusion Frequency (CFFF)

The CFFF indicator is the result of the Flicker Test, represented by ascending and descending thresholds, measured in Hz.

In the case of the ascending threshold, the frequency of light flickering increases (beginning at 30 Hz) and the participant should react (press a button) when he sees the light stop flickering. In the case of the descending threshold, the frequency of light flickering decreases (begins at 50 Hz) and the participant reacts when he sees the beginning of light flickering.

In this study six replicate measurements of ascending and descending thresholds were performed.

The Flicker Test was realised with a Dufour (France) apparatus (type PV 8), which permits binocular observation of the flickering light source, without access of outside light.

In the black tube of this apparatus, the participant sees a centrally situated red flickering light, whose surface is 1 cm^2 and whose light intensity is 7.8 mililamberts. There are also eight red diodes, not flickering, around the central light. The tube is 50 cm long. The range of flicker frequency was 0-100 Hz. The speed of light frequency change was 1.5 Hz/s.

2.4. Procedure

Each person participated in the experiment for about 7 days (the average number of experiment days for one participant was 6.8). The experiment was carried out from October to February (during autumn and winter). Therefore, they were neither the same days for each participant nor 7 consecutive days. The Flicker Test was conducted twice a day: in the morning, that is, before work (6-8 a.m.) and in the afternoon, that is, after work (1-3 p.m.). The FCB-TI was completed once during the period of the experiment.

Sight parameters were not controlled. Participants who wore glasses decided whether to perform the Flicker Test with or without them, taking into account the necessity to see the light clearly. There was no case of daltonism.

3. RESULTS

Before reporting the results of a statistical analysis of the relationship between temperament and CFFF, it is very important to make the following remark: The general overview of the CFFF results indicates that two groups can be distinguished among participants on the basis of the type of reaction to the Flicker Test. This result appears essential for the main statistical analysis.

The first group was characterised by a lower CFFF ascending than descending threshold. Because the hypothetical point of the light flicker/fusion is probably situated between the level of the ascending threshold and the level of the descending one, we suspect that the

participants in this group probably reacted (pressed the button) before they noticed the light flicker disappear (in the case of the ascending threshold) or appear (in the case of the descending threshold). Their model of reaction in the Flicker Test suggests that their actions were governed by impulsiveness and that they did not have to make sure that their reactions were correct. For this reason this group was called Reckless. The difference between the averages of CFFF ascending and descending thresholds was statistically significant.

The second group had a different reaction model in the Flicker Test. It is characterised by a higher CFFF ascending threshold than the descending one. For the same reason as in the first case, we suspect that the persons from this group probably had to be sure that they were not wrong and therefore they reacted later than they had noticed the light flicker disappear (in the case of the ascending threshold) or appear (in the case of the descending threshold). For this reason, in spite of the fact that the difference between ascending and descending thresholds was not statistically significant, we decided to distinguish this group and to call it Unsure. Table 1 presents the statistical characteristic of the CFFF value for both groups.

TABLE 1. Average Values of Ascending and Descending CFFF Thresholds for Two Groups, Reckless (R) and Unsure (U), Separately for Measurements Before Work and After Work

		Measurements Before Work		Measurements After Work	
Participants	*N*	Ascending Threshold (Hz)	Descending Threshold (Hz)	Ascending Threshold (Hz)	Descending Threshold (Hz)
U	25	36.50	35.59	36.62	35.67
R	45	36.94	38.42	36.96	38.45

Notes. CFFF—Critical Flicker Fusion Frequency, U—Unsure persons: the CFFF ascending threshold is higher than the descending one; R—Reckless persons: the CFFF ascending threshold is lower than the descending one.

In the case of the Reckless group, the difference between the averages of CFFF ascending and descending thresholds is as follows:

- -1.49 ($p<.05$, $N=45$) for measurements before work,
- -1.49 ($jx.05$, $N = 45$) for measurements after work.

Also, in this group the CFFF level changes significantly (increases) after work:

- the value of the difference between the averages of the CFFF ascending threshold before work and after work is -0.03 *(p<.05, N* = 45),
- the value of the difference between the averages of the CFFF descending threshold before work and after work is 0.03 *(p* < .05, *N* = 45).

In the case of the Unsure group, the value of the difference between the averages of CFFF ascending and descending thresholds is

- 0.90 *(p* < .05, *N* = 25) for measurements before work,
- 0.94 *(p* < .05, *N* = 25) for measurements after work.

In this group the level of CFFF changes (increases) after work, but not significantly: The value of the difference between the averages of the CFFF ascending threshold before work and after work is -0.12 (p<.O5, *N* = 25), the value of the difference between the averages of the CFFF descending threshold before work and after work is -0.09 *(p<.05, N* = 25).

There is a significant difference between the Reckless and Unsure groups from the point of view of the average values of the CFFF descending threshold: The value of the difference between the averages of the CFFF descending threshold, in the case of measurements before work is 2.84 (p<.O5, *N*= 70); the value of the same difference for measurements after work is 2.78 (p<.05, *N=70).* The descending threshold in the Reckless group is higher than in the Unsure one.

To check the hypothesis about correlation between temperament and CFFF, correlation between temperament attributes and the following CFFF statistic dimensions were calculated:

1. average CFFF values,
2. diurnal CFFF changes,
3. the difference between ascending and descending thresholds,
4. the CFFF coefficient of variance (CV).

All these relationships were calculated for the following groups:

- All participants,
- the Reckless group,
- the Unsure group.

In the case of points 1, 2, and 4, the relationship was calculated separately for ascending (Asc) and descending (Des) thresholds. Table 2 presents the results of this statistical analysis.

TABLE 2. Correlation Between Temperament Attributes and CFFF Statistic Dimensions

CFFF Statistic Dimensions		Temperament Attributes											
		Briskness			Perseverance			Sensory	Emotional Reactivity				
Group	Threshold	*r*	*N*	*p*	*r*	*N*	*p*	Sensitivity	*r*	*N*	*p*	Endurance	Activity
Asc — Des Difference													
U		−.3778	31	.0361		—		—		—		—	—
Coefficient of Variance (*CV*)													
All	Asc	−.2508	80	.0248		—		—		—		—	—
R	Asc		—			—		—	−.2933	49	.0408	—	—
	Des		—		−.2958	49	.0391	—		—		—	—
U	Asc	−.4228	31	.0178		—		—		—		—	—
	Des	−.5012	31	.0041		—		—		—		—	—

Notes. CFFF—Critical Flicker Fusion Frequency, All—all participants, U—Unsure group, R—Reckless group, Asc—ascending threshold, Des—descending threshold.

1. The results of the statistical analysis (Linear Correlation Coefficient) indicate that there was no statistically significant correlation between temperamental characteristics and two CFFF statistic dimensions: average values and diurnal changes.
2. There was one statistically significant correlation between Briskness and the difference between ascending and descending thresholds in the case of Unsure persons: $r = -.3778$ ($p<.05$, TV =31).
3. There was also one statistically significant correlation between Briskness and the CFFF coefficient of variance: $r = -.2508$ ($p<.05$, $N = 80$).
4. The most statistically significant correlation was found for temperament attributes and the CFFF coefficient of variance, when the coefficient of variance was calculated separately for the Unsure and Reckless groups.

There was correlation between the CFFF coefficient of variance and the following three temperament attributes:

- Briskness
  - For the Unsure group, in the case of the ascending threshold: r = -.4228 ($p = .02$, $N= 31$),
  - For the Unsure group, in the case of the descending threshold: r = -.5012 (p= .004, $N= 31$).

This correlation means that in the group of Unsure persons, a high level of Briskness coincides with a low level of *CV* (both in the case of ascending and descending thresholds).

- Perseverance
  - For the Reckless group, in the case of the descending threshold: r = -.2958 ($p = .04$, $N = 49$).

This correlation means that in the group of Reckless persons, a high level of Perseverance coincides with a low level of *CV* (in the case of descending threshold).

- **Emotional Reactivity**
  - For the Reckless group in the case of the ascending threshold, $r = -.2933$ ($p = .04$, $N = 49$).

This correlation means that in the group of Reckless persons a high level of Emotional reactivity coincides with a low level of *CV* (in the case of the ascending threshold).

It was also determined whether there is a difference between Unsure and Reckless participants from the point of view of the level of each temperament parameter.

A statistically significant difference was found only for Sensory sensitivity (Kruskal-Wallis analysis test statistic = 4.70, /; = .03). The average value of this temperament parameter was higher for Reckless participants (15.96) than for the Unsure group (13.84).

4. DISCUSSION

The results of the study indicated that there were no direct relationships between the CFFF level and temperamental characteristics in the analysed group of participants.

The dependencies appeared when one of the CFFF dispersion measures (coefficient of variance) instead of CFFF average values was taken into account. In this case, there was correlation between Briskness and CFFF *CV.*

Most relationships appeared when the correlation between CFFF *CV* and temperamental characteristics was calculated for two groups, differing in the type of reaction in the Flicker Test.

These results are interesting when we agree that CFFF *CV* could be treated as an indicator of behavioural stability, which permits predicting future behaviour. Persons with low CFFF *CV* are more focused, their reactions are more consistent and less random, so, perhaps, their behaviour could also be more effective than in the case of persons with high CFFF *CV,* who are less stable in their actions and their reactions are not consistent.

Accepting this assumption, the obtained results could be interpreted in the following way: The combination of one type of reaction with its temperamental opposition—Briskness in the group of Unsure persons and Perseverance in the group of Reckless persons—causes an increase of behavioural effectiveness (CFFF *CV* decreases).

A different result was obtained in the case of Emotional reactivity in the group of Reckless persons: Behaviour effectiveness goes with a high level of this temperamental characteristic. At first, this seems impossible. However, according to Kofta (1979), the relationship between behavioural impulsiveness and emotional reactivity is regulated by personality factors like, for example, intelligence: Despite high emotional reactivity a person is able to behave effectively if he or she has a high level of intelligence. The reason is that

intelligence is connected with knowledge about techniques useful for emotional control. Taking into account that the participants were managers, it is possible to assume that their intelligence level was high enough for them to manage with high emotional reactivity.

It seems to be interesting that Unsure and Reckless participants differ in the level of sensory sensitivity and the level of the descending CFFF threshold: The Reckless group has higher sensitivity to the perception of light flicker appearance. This group can see it earlier than Unsure participants.

We do not know now why there are two reaction types in the Flicker Test. The assumption is that reactivity, not only in the emotional sense, could influence the relation between ascending and descending CFFF thresholds. However, this hypothesis requires future studies. The results we have obtained indicate that another possible explanation is that the ratio of the ascending/descending threshold is caused by sensory sensitivity in the capacity of light flickering perception.

5. CONCLUSIONS

The hypothesis about the relationships between the three temperamental characteristics, Activity, Emotional reactivity, Briskness, and the CFFF level was not confirmed. However, the obtained results indicate that Emotional reactivity, Briskness, and Perseverance could be important factors in increasing behavioural effectiveness if they are connected with their opposite human attributes manifested in one of the reaction types: abstinence (Unsure persons) or spontaneity (Reckless persons).

From the methodological point of view, it seems well-founded to take into account the division into Unsure and Reckless persons when inteipreting CFFF results. It could be interesting to check in the future a hypothesis about the stability of those types of reactions.

It is worth pointing out that only one from among other checked CFFF statistical dimensions, the coefficient of variance *(CV),* appeared significant in relationships with temperament attributes. Perhaps this dimension is better in statistical analysis of CFFF results than other ones because it contains more information.

The results of the statistical analysis of the relationship between CFFF and temperament attributes indicate interesting points in this area of research. They require further experiments with larger groups of participants.

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