Personality and Individual Differences 66 (2014) 98–101

Contents lists available at ScienceDirect

Personality and Individual Differences

journal homepage: www.elsevier.com/locate/paid

Short Communication

Disruption of circadian rhythmicity – An exploratory study in Poland

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ARTICLE INFO

Article history:
Received 15 November 2013
Received in revised form 28 February 2014
Accepted 5 March 2014
Available online 17 April 2014

Keywords:
Blue light
Computerization
Morningness
Eveningness
Men
Women

ABSTRACT

A comparison of the ratio of morningness/eveningness among students in the years 2005 and again 2011 in Poland revealed an increase in the number of people preferring evening activity (from 15.5% to 27.5%) and a decrease of morning type individuals. The only factor which undergone a change during this time is the number of personal computers with internet access (from 38.8% to 65.2%). We assume that the shift in the ratio of the chronotypes in both studies may have occurred due to affecting the circadian clock by the blue light emitted by computer screens.

1. Introduction

Circadian rhythm of sleep and wake has been under investigation for almost 50 years and the main tool for this research is a range of several questionnaires, among which the one created by Horne and Östberg (1976) is frequently used for determining the preferred time of top circadian activity. In terms of social and living conditions student's group can be considered as quite homogenous. It usually consists of people in their twenties, in good health and living in similar conditions (student dormitories, rented flats), but what is the most important here – they are able to shape their daily schedule mostly by themselves. The significance of the latter social factor has been proved by the study on the circadian rhythm in two similar ethnic and age groups of young people: students and white-collar workers (Mecacci & Zani, 1983). During the last decade another factor able to affect the morningness–eveningness preferences in young people has emerged – an increasing number of personal computers and similar devices. The nature of the influence of this factor is dual: as a way of spending time (entertainment, brain activity) and as physical agent, namely – a source of blue light emitted by the screen. In the first case, long-term computer use may lead to deficit in sleep and sleepiness during the following day, while the impact of blue light does not necessarily lead to lowered alertness, performance and efficiency on the day after (Lockley, 2009). The difference between the modes of action of those two factors is that a simple fact of staying interested in some activity (like playing a computer game and chatting) does not affect the functions of circadian clock, while blue light may directly, via extraoptical perception (Münch et al., 2006; Cajochen et al., 2011; Berson, Dunn, & Takao, 2002), cause changes in the circadian clock's functioning. As this kind of light causes a shift in the time of top concentration of melatonin (Lockley, 2009), it also creates conditions for a prolonged evening activity. Furthermore, if the change in the brain's bioelectric activity is not followed by impaired concentration on the day after (Cajochen et al., 2005; Lockley, 2009), the person does not suffer much discomfort of staying awake for long hours, which fosters repetition of this behavior, which leads to consolidation of the changes made to the chronotype. Both facts create good conditions for an increase in the number of people declaring preference of evening activity.

The research on whether blue light of the computer screen may affect the ratio of "larks" and "owls" (i.e. morning and evening types, respectively) is only possible by means of a questionnaire on circadian preferences of a socially homogenous group of people, differing only by the fact of being or not being exposed to this light. This condition was met by Polish students interviewed in the years 2005 and 2011, as during this span of time the number of computers with Internet connection in Poland rose from 38.8% to 65.02% (years 2005 and 2011 from www.factfish.com/statistic-country). Duffy, Kronauer, and Czeisler (1996) states that "behavioral stimuli are relatively weak circadian synchronizers in humans". Similarly, Mistlberger and Skene (2004) in their review paper additionally confirm no influence of social factors and other nonphotic time

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http://dx.doi.org/10.1016/j.paid.2014.03.007
0191-8869/

cues on pattern synchronization, even in bilaterally enucleated subjects.

2. Materials and methods

In order to determine whether and to what extent the students are exposed to the blue light of computer screens, we inserted some additional questions to Horne and Östberg's questionnaire. This data were confronted with the interviewees' chronotype, determined by means of a typical Horne and Östberg's questionnaire.

First interviews for this study, using Horne and Östberg's questionnaire, were performed in 2005 on both male and female students of the Nicolaus Copernicus University (NCU) in Toruń (Tęgowska, Ciszewski, & Gąsiorowski, 2006; Tegowska, Gasiorowski, & Ciszewski, 2007). During this time students dormitories of NCU did not have the access to the internet and only as little as 20% students possessed personal computers.

In the total range of data (558 questionnaires) obtained in 2005 and published in the years 2006–2007, 50.4% of the questionnaires were filled by male students (227 persons) and 49.6% (223 persons) by female students. In the present paper the analysis is based only on 450 questionnaires completed by students (range 19–28 years). After 5 years 609 students of the same university (307 (48.7%) women and 302 (51.3%) men) were asked to fill the same questionnaire concerning morningness–eveningness, however, in this time the internet access was available in all students dormitories (reports by UCI 2005 from www.uci.umk) and about 80% students possessed personal computers. Then four additional questions were included: about the mean time spent in front of computers daily, on working days and holidays as well as the time of day when the exposition usually occurs. We also analyzed homogeneity of our group, verifying how many people of a given chronotype were in the age groups of 19–22 and 23–26. It was concluded that there were no differences within the group, because e.g. the "larks" group in 19–22 years-old differs from the "larks" group in 23–26 years-old by 3%. Analogically small differences were observed in the "owls" group. In that respect, this group is homogenous. The significance of the difference in the number of students of morning or evening chronotype was determined using the chi-squared test and *z*-score. To test if the proportions of types differed among years, gender and time spent in front of a computer, we performed 3-way log-linear analysis with the following factors: (1) year; (2) gender; (3) type or (1) gender; (2) type; (3) using computer within selected time intervals. If necessary, for significant interactions, we conducted 2×2 *G*-tests to find out which groups significantly differ from one another. All analysis were performed in IBM SPSS Statistics 20.

3. Results

Within the 5 years under the study, the number of morning types decreased, while the number of people preferring evening activity increased (Table 1). The changes occurred in both sex groups, however, the changes were larger within the group of "larks" than in "owls", and in regards to sex groups – in women rather than men. In the group of female students interviewed in 2005 there were more "larks" than "owls" (20.2% vs. 5.8%), later the trend inverses (16.6% vs. 20.5%). A comparison of the number of morning and evening types using computer after 8 pm reveals that the latter type tends to spend more time in front of it (especially on weekends and holidays; Table 2). The most significant rise in this matter can be observed in women (by 13%). Unfortunately, the additional questions to Horne and Östberg's questionnaire did not cover a total weekly time of exposition to the light emitted by the screens. The research conducted now include this amendment.

4. Discussion

According to the data available to us, the number of students preferring morning activity ranges from 2.4% in Canada (2007), 6.5% in Poland (presently), 8.3% in the USA (1997), 15.8% in Spain/Italy (2002), 17.9% in Germany (2007), 18% in Canada (2002), 18.2% in Saudi Arabia, 19.1% in Turkey, to 22.5% in Poland (2005), respectively by: Jovanovski and Bassili (2007), Tęgowska et al. (2007), Tęgowska et al. (2006), Chelminski, Ferraro, Petros, and Plaud (1997), Adan and Natale (2002), Lehnkering and Siegmund (2007), Rufiange, Dumont, and Lachapelle (2002), BaHammam, Almestehi, Albati, and AlShaya (2011), Beşoluk (2011). It is, however, to discern the reasons behind differences, as the data were collected in various geographic latitudes. We also find those data non-comparable due to the fact that they were obtained in different years, and the level of computerization of each of those countries was diverse in the time of collecting the data. We can, however, compare the rate of people declaring themselves as "larks" in the given country in the years when 50% of the society did not have the access to internet (group I: Turkey 42.1%, USA 7.4%, Spain/Italy 20.4% and 28% respectively, Poland 38.8%, Saudi Arabia 47.5%) with similar data obtained after the ratio of connection to Internet in the society exceeded 50% (group II: Germany 75.4%, Canada 61.4%, Canada 73.3%, Poland 65%) (www.factfish.com/statistic-country). Similar calculation can be performed to determine the prevalence of evening chronotypes. By means of such analysis it can be observed that in the first group the mean ratio of "larks" is 16.8% (19.1% for Turkey, 8.3% for USA, 15.8% for Spain, 22.5% for Poland and 18.2% for Saudi Arabia) while in the second it is as low as 11.2% (17.9% for Germany, 2.4% and 18.0% for Canada and 6.5% for Poland). The opposite tendency takes place in the case of "owls", where the ratio is 28.6% for the first group and 35.1% for the second. By all means, it is difficult to discriminate the influence of entertainment provided by the Internet from the effect of the blue light of the screen. It is however a well-known fact that this band of light wavelength shows properties which could at least foster night activity: it delays the top secretion of melatonin, moderates the perceptible symptoms of sleepiness and prolongs the duration of core body temperature maximum (Lockley, 2009; Münch et al., 2006). The impact of blue light, mainly on retinal ganglion cells containing melanopsin (Lockley, 2009; Münch et al., 2006) and on human circadian rhythms (Hattar, Liao, Takao, Berson, & Tau, 2002) was described several years ago. It was also shown that the screens with diodes emitting blue light delay and lower the top secretion of melatonin and affect EEG in a way indicating a diminished sleepiness (Cajochen et al., 2011).

If the decrease in the number of "larks" observed in our study was not a coincidence, but an effect of the blue light from the computer screen, the same phenomenon should be noted in other countries. In order to be able to compare the data, the research should be performed either on the population of students with diverse access to the internet or in the country where the level of computerization has much changed within about 5 years. According to our best knowledge the only studies meeting such provisions were performed on Canadian students (Jovanovski & Bassili, 2007; Rufiange et al., 2002), where the morningness–eveningness research was repeated after 5 years. Their results reveal that the number of people preferring morning activity dropped 6-fold, while the number of evening-type persons rose thrice. This may be confronted with the statistic data showing that during these 5 years the rate of computerization in Canada rose from 61.44% to 82.68% (www.factfish.com/statistic-country). Similarly to the