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Effect of Subjective and Objective Workload on Asthenopia at VDU Workplaces

Thomas Stüdeli
Marino Menozzi

Institute of Hygiene and Applied Physiology,
Swiss Federal Institute of Technology
Zürich, Switzerland

An ergophthalmological tool has been developed to investigate effects of subjective and objective workload on work-related visual complaints (asthenopia). In field studies on different visual display unit (VDU) workplaces effects of objective and subjective workload, work intensity, and work breaks (5–9 min/hour) could be found. It could be shown that during the first hours of VDU work, asthenopic complaints have the tendency to follow effective workload. With increasing working time the effect of a general and visual fatigue overlaps other reported visual complaints in the majority of cases.

asthenopia actual asthenopic complaints actual psychological strain
workload customer call center stock broker

1. INTRODUCTION

After musculoskeletal discomfort, eye discomfort is the second most frequent problem reported by visual display unit (VDU) operators. About 10% of VDU users have severe asthenopic complaints and 30% of VDU users frequently report asthenopic complaints like blurred vision, ocular soreness, blinking, heaviness of the eyes, itching of the eyes, or double vision (Cole, Maddocks, & Sharpe, 1996; Mocci, Serra, & Corrias, 2001).

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Correspondence and requests for offprints should be sent to Thomas Stüdeli, Institute of Hygiene and Applied Physiology, ETH Zürich, ETH-Zentrum, CH-8092 Zürich, Switzerland, E-mail: <stuedeli@iha.bepr.ethz.ch>.

Knowledge that links asthenopia, eyestrain, or visual fatigue to prolonged visual work at near distances was available as early as 1935 (e.g., Luckiesh & Moss, 1935). Asthenopia has been deeper investigated since the 1950s with the introduction of the fluorescent lamp, long before VDU work was important (Schierz, 2003). Therefore asthenopic complaints of VDU users have been investigated since the very beginning of ergonomic research on VDU workplaces (Cole et al., 1996; Läubli, Hunting, & Grandjean,1981).

In the last 20 years a large number of studies on work-associated eye strain have been published. The cause of eye strain is assumed to be individual and it is based on several physiological and external factors. Among external factors causing asthenopia, psychological workload (stress; Mocci et al., 2001; Smith, 1997), lightning condition (Schierz, 2003; Wolska & Śwituła, 1999), technical and other ergonomic factors (Aarås, Horgen, Bjørset, Ro, & Thoresen, 1998; Läubli et al., 1981) have been identified. With the current research doctrine the influence of psychological strain on asthenopia can be taken for granted. To what extent psychological strain influences visual strain is more difficult to show and subject of current ergophthalmological research.

Mocci et al. (2001) combined three questionnaires: the National Institute for Occupational Safety and Health (NIOSH) general job stress questionnaire (factors), an asthenopia questionnaire, and a questionnaire about subjective discomfort in the working environment (noise, humidity, temperature, smoke, stale air, illumination, and crowding). In a field study Mocci could affirm the described correlations between asthenopia and psychological strain. Next to the environmental factors (smoke and noise) the following psychological factors showed correlations with visual complaints: role stressors, social support, workload, underuse of skills, work satisfaction, interpersonal conflict, self-esteem, and mental workload, but not physical workload. Although extended field studies could confirm the described correlations between asthenopia and several stress factors (Mocci et al., 2001) these results can only support practical know-how. Several authors assume biases and interactions of the subjective rating of workload and the rating of asthenopic complaints. To avoid this, objective measurements of workload have been proposed.

2. AIMS

The fact that ergonomic factors as well as psychological strain affect asthenopia, leads to the question how much the type of work, work intensity, and the management of work hours (e.g., breaks) may affect visual complaints. Few statements about the influence of work intensity or the length of daily pauses (Leodolter, Lindorfer, & Jäger, 1996) on asthenopia can be found.

To investigate these factors an analysis of asthenopia must be done on specific workplaces, during normal work, with high frequencies. With the current asthenopic questionnaires the claimed frequencies cannot be achieved, because the surveillance of 6 (Mocci et al., 2001; Tyrell & Leibowitz, 1990), 10 (Wolska & Śwituła, 1999), or even 30 (Yoshitake, 1978) different visual symptoms would take too much time.

To quantify and examine asthenopic complaints, subjective and objective workload related to practice, all these factors have to be to investigated at the same time. Therefore an ergophthalmological tool has been developed considering these requirements (Stüdeli, Bellaïche Shavit, & Menozzi, 2001; Volger, Stüdeli, & Menozzi, 2003). The first experiences and results with this new tool are presented here.

3. MEASUREMENT OF CURRENT ASTHENOPIC COMPLAINTS

Visual complaints can be recorded on a long-term, retrospective basis (Mocci et al., 2001) or by registering current asthenopic complaints in the short term. As the purpose of the study was to have repeated assessments, the time horizon of the assessed asthenopic complaints was reduced to a minimal amount of time (Stüdeli et al., 2001).

The recovery time of different asthenopic complaints has become controversial, due to a multitude of different definitions and measurements and the diverse causal disposition (nature) of asthenopia. Indications of this controversy can be found easily. During their experiments, Miyao, Hacisalihzade, Allen, and Stark (1989) showed a recovery time of less than 1 min and Läubli et al. (1981) ascertained the fact that eye impairments are measurable even the next morning. Therefore, focusing on current complaints turns out to be more useful.

The questionnaire was built from three short questions, which recorded current asthenopic complaints: “Do you have visual complaints at this moment?,” “Do you have a headache at this moment?,” and “Quantify your visual strain of today.” To all three questions the participants added a value between *nothing* and *very strong* either on a Leikert scale range from 0 to 10 or on a visual analog scale of 10 cm (Stüdeli et al., 2001).

4. MEASUREMENT OF CURRENT PSYCHOLOGICAL STRAIN

To measure current psychological strain of the participants, a standardized questionnaire KAB (Kurzfragebogen zur aktuellen Beanspruchung in German; Questionnaire of the current psychological strain) was used. This questionnaire was filled out within half a minute and correlated with the self-assessment of both experienced and expected current strain (Müller & Basler, 1993).

In the KAB questionnaire, the participants had to rate their psychological state in 5 dimensions on opposite pairs of adjectives. Participants quantified their current strain using a scale ranging from 1 to 6. The question to be answered was: "Now I feel.…" The scales were as follows:

- *released* 1—2—3—4—5—6 *oppressive,*
- *worried* 6—5—4—3—2—1 *mindless,*
- *relaxed* 1—2—3—4—5—6 *restive,*
- *skeptic* 6—5—4—3—2—1 *trusting,*
- *comfortable* 1—2—3—4—5—6 *unwell.*

The average rating gave the current psychological strain index.

5. FIELD STUDIES

To investigate the coherence of asthenopia and psychological strain, we conducted a study under laboratory conditions and field studies at different VDU workplaces like the stock market (bank office), a customer call centre, and a technical high school. These studies helped us to improve the method and change the questionnaire technique from a paper questionnaire to an electronic questionnaire (Stüdeli et al., 2001), to a web-based electronic questionnaire (Volger et al., 2003), and finally to a full electronic questionnaire program.

5.1. Search Task (Laboratory)

Combined mental and asthenopic self-assessments were examined using 12 participants in a display-related search task in the laboratory. The total required to complete the task varied from 30 to 65 min. The participants scanned 240 matrixes of 40 × 40 capital letters E presented on a display. In 50% of the presented matrixes one letter E, at any location, was replaced by a capital letter F. The participants were asked to report, as soon and as accurately as possible, whether one of the letters in the matrix had been replaced or not. The answer and reaction time were recorded. An extensive description of the search task can be found in Menozzi, Näpflin, and Krueger (1999) and Menozzi, Lang, Näpflin, Zeller, and Krueger (2001). Before and after completing the task, the participants had to fill out the two questionnaires. Every 40 matrixes (5–10 min), the participants could take a short break of 5 to maximal 30 s.

5.2. Daily Work on VDU (Field)

Nine stock brokers working in the same bank office filled out our questionnaires three times during work hours: in the morning, before they started to work (about 7 to 8 a.m.), just before the lunch break (about 11.30 a.m.), and in the evening at the end of the work (5 to 7 p.m.).

The questionnaires were also applied in a second field study, in which the suitability of two display technologies for office work was rated. Six Ph.D. students of the Institute of Hygiene and Applied Physiology (IHA, ETH Zürich, Switzerland) were investigated three times a day during a period of at least 10 work days with more than 4 hrs of VDU work. The participants worked at least 5 days on a Cathode Ray Tube (CRT) display and 5 days on a LCD-TFT (Liquid Crystal Display-Thin-Film-Transistor) display. They completed their usual work without restrictions.

In a third field study, the measurements could be done with a full electronic questionnaire program during entire work days in a customer call center. The 20 participants, operators working in three shifts from 6 to 7 p.m., completed their usual work without restrictions. The questionnaire program was installed on all data terminals and started in the morning with the beginning of work of the participants. Every hour the participants were asked by the program to rate visual complaints and current psychological strain. During the entire work day, the program measured objective workload by counting the key strokes on the keyboard.

6. RESULTS

6.1. Search Task

Results of the three questions on current asthenopic complaints correlated with the psychological index (Pearson: complaints $p = .51$, headache $p = .65$, and strain $p = .54$). There was a tendency of lower psychological strain but higher visual complaints for participants that solved the visual task in a short time. Self-assessed psychological strain rose from 37% before, to 47% after the task. At the same time visual complaints rose from 17 to 36% (Figure 1).

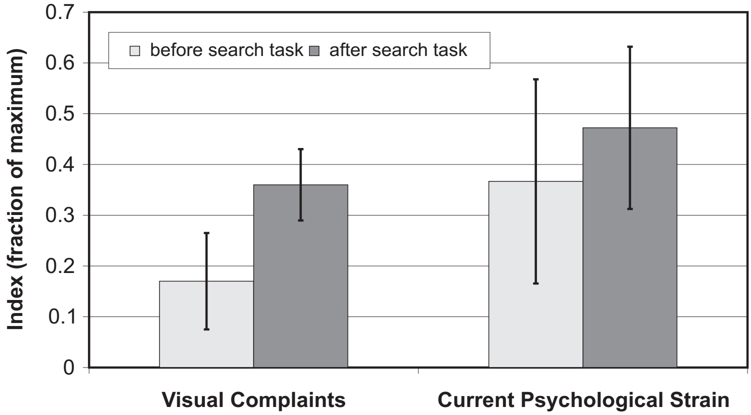

Figure 1. Increase in visual complaints and current psychological strain (KAB) through intensive visual display unit (VDU) work of 30–65 min (*n* = 12). *Notes.* KAB—questionnaire of the current psychological strain (Kurzfragebogen zur aktuellen Beanspruchung).

To compare the two different indexes, results of both indexes are presented here as a fraction of the maximal value. In our experience the ratings of psychological strain are generally higher than reported asthenopic complaints with the questionnaires used (see Figures 1, 2, and 3).

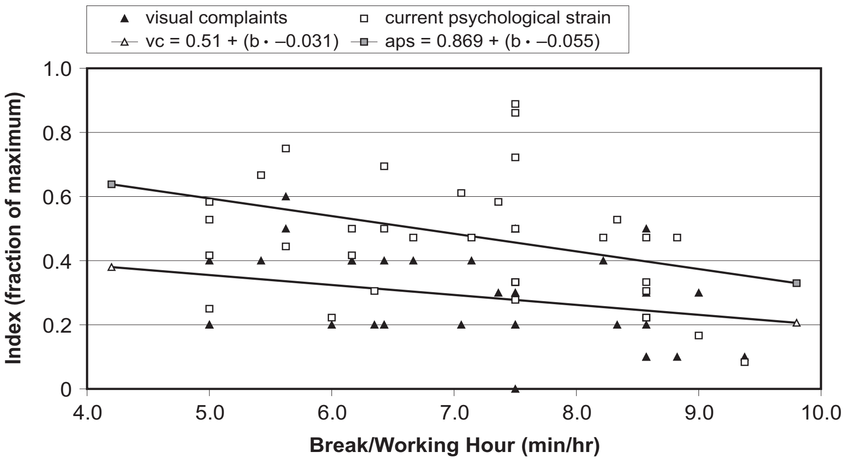

Figure 2. Influence of breaks during work hours on visual complaints and on psychological strain of brokers at the end of a work day. *Notes.* Ratings of visual complaints of 36 brokers are represented with triangles, ratings of current psychological strain are represented with squares.

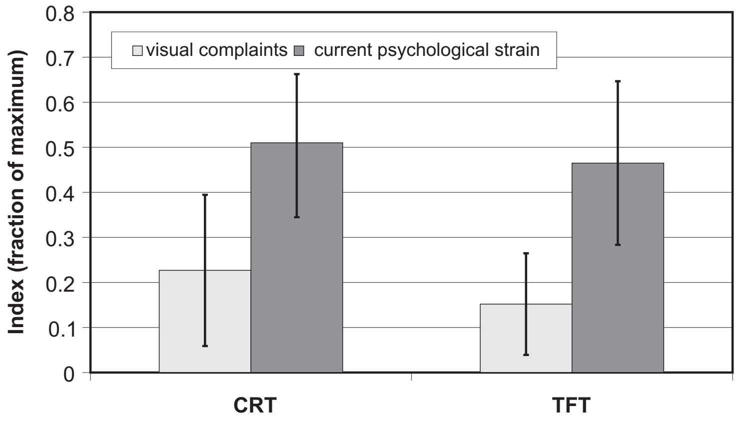

Figure 3. Comparison of asthenopic complaints and the index of current psychological strain in the evening after work on Cathode Ray Tube (CRT) and Thin-Film-Transistor (TFT) displays. The results show averages for all participants (n = 9) over 6–13 days.

6.2. Daily VDU Users

On average the brokers worked 7.2 hrs/day on TFT displays. During work hours the participants rested 52 min/day or 7.2 min/hr. The average effective work time was 8.2 hrs/day. Figure 2 shows visual complaints and psychological strain computed using 36 evening questionnaires. Only normal office days with a high proportion of VDU work and with reported times of breaks between 5 and 9.5 min per hour of work time were taken into account.

There was a tendency of lower asthenopic complaints ($p = -.28$) and strain ($p = -.3$) after work days with longer breaks (Figure 2) for participants after work days with a better break-work ratio. Unfortunately no statements can be made about the influence of the distribution of breaks during the day on asthenopic complaints or subjective workload.

In the second study (a technical high school), the participants reported different asthenopic complaints after working on CRT and the TFT displays. Five out of six participants listed fewer asthenopic complaints after working with a CRT display than after working with a TFT display.

After more than 5 hrs of VDU work, they reported visual complaints of 15% (TFT) and 23% (CRT) of the maximum (full scale). Visual strain using TFT (28%) was rated lower than when using CRT (34%) displays. For the same time, no differences in psychological strain and headache was found (see Figure 3).

On average, the Ph.D. students worked 3.8 hrs/day on CRT or TFT displays. During work hours the participants rested 52 min/day or 15 min/VDU-hour. The average effective work time was 8.2 hrs/day (n = 220).

The ratings in Figure 3 show that working in an academic environment caused similar psychological strain but fewer visual complaints than work as a stock broker (Figure 2).

6.3. Objective Workload and Visual Strain in the Customer Call Center

On average the operators worked 8.2 hrs/day in the customer call center. During work hours the participants rested between one and five times (mean number of breaks: 2.17 ± 0.99) on the one hand assigned by shift work management, on the other hand also caused by personal interests.

Figure 4 shows mean values (n = 8–58) of the hourly (6 a.m. to 7 p.m.) reported visual strain and continuously measured objective workload (computer activity) from 58 work days of 7 operators on the same shift.

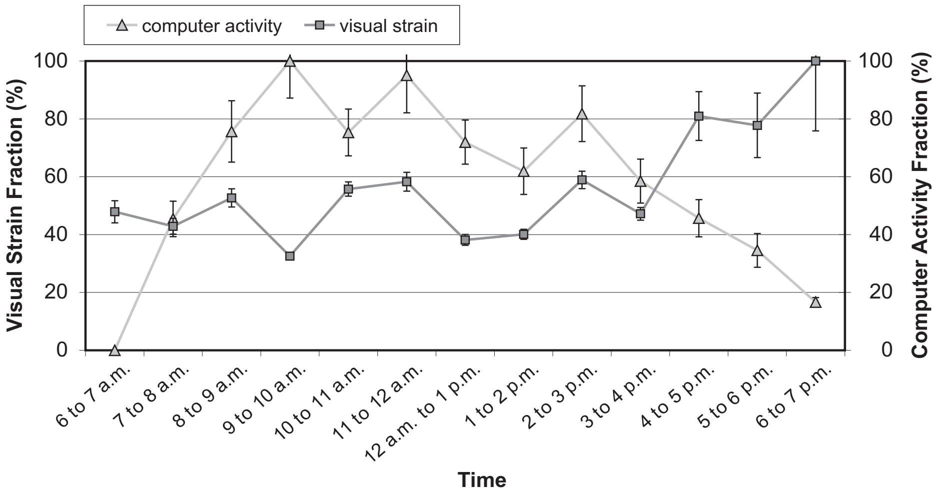

Figure 4. Comparison of reported subjective visual strain and objective workload measured by key strokes during a work day at a customer call center. The data indicated are mean values of 8–58 measurements.

The work day can be divided into marginal work hours (6–8 a.m. and 5–7 p.m.) characterized by lower workload (<50% of maximal computer activity) and prime work hours with rather higher workload (>50% of maximal computer activity), with three peaks at 9 a.m., 11 a.m., and 3 p.m. (Figure 4). The highest achieved computer activity was 5,892 key strokes per operator and hour.

The reported current psychological strain at the end of work was lower (mean, fraction of maximum: 34% ± 24) than the reported strain for brokers or Ph.D. students. We interpret this result as a characteristically low workload phase at the end of the day.

The reported visual strain had the tendency to follow the workload during the day and showed a strong rise in the evening. The cause of this conspicuous effect might be found in general or work-related fatigue.

7. DISCUSSION

Work on a VDU is visually demanding and provokes asthenopic complaints. Asthenopic complaints rise during work whereas psychological strain does not show this tendency. In our laboratory conditions, the effects of psychological strain from "outside the experience" can be taken as minimal. The measured strain is provoked by a demanding monotonous search task. Fast fulfillment of the task, which also meant higher work intensity and workload, lowered psychological strain of the participants, but raised visual complaints. We assume motivational reasons for this effect.

The results show that short work breaks influence asthenopia as well as work intensity. Note the difference in visual complaints between Figure 2 (brokers) and Figure 3 (Ph.D. students). These differences in visual comfort cannot be explained by different psychological strain or display technologies.

For the moment, the assessment of asthenopic complaints is still rather complex. Visual complaints and their perception vary considerably during the day. Under laboratory conditions short-time effects of workload on asthenopia can be described (see section 6.1), because some of the factors that shift the perception of eye ailments are stable or can be controlled.

The development of our tool led us to a computer program that helps to achieve almost continuous measurements of asthenopic complaints, psychological strain, and objective workload. Fast and easy measurements can help us to give a helping hand to those who have asthenopic complaints. A future practical application could be to support specialists in stress and relaxation management of VDU work. In future, when the influencing factors of work-related visual symptoms are better known, asthenopia can play a major role in risk prevention at workplaces. Even nowadays it should be considered as serious as visual acuity.

Biases and interactions of the subjective rating of workload and the rating of asthenopic complaints are likely. However the perception of these shows differences, as we found and as Murata, Uetake, Otsuka, and Takasawa (2001) described. To interpret the almost continuous data we have to take this fact in account.

Asthenopic complaints have the tendency to rise during intensive working periods without breaks: The subjective feeling of eye strain or visual fatigue—in this state—is close to the perception of work intensity, whereas self-assessed psychological strain is influenced by the perception of the success at work and it is closer to motivational aspects.

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