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Ergonomics of human-system interaction - Part 393: Structured literature review of visually induced motion sickness during watching electronic images (ISO/TR 9241-393:2020)

Ergonomie de l'interaction homme-système - Partie 393: Titre manque (ISO/TR 9241-393:2020)

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Ergonomie de l'interaction homme-système - Partie 393: Titre manque (ISO/TR 9241-393:2020)

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European foreword

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The text of ISO/TR 9241-393:2020 has been approved by CEN as CEN ISO/TR 9241-393:2022 without any modification.

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Foreword

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This document was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 4, *Ergonomics of human-system interaction*.

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A list of all parts in the ISO 9241 series can be found on the ISO website.

Introduction

Recent advancements in moving image technology have enabled us to view and interact with images using various display devices and in various ways. Moreover, application fields are not limited to entertainment but also to other business scenarios with the expectation to expand to more ambitious applications.

In terms of the expansion of application fields and utility forms, the role of video images serving society has become increasingly important. Thus, it has become necessary to consider the ergonomic aspects of utilizing video images in view of further progressive expansions. In relation to ergonomic aspects, we need to consider not only the specifications of devices but also those affecting image safety, including those for reducing visually induced motion sickness, or VIMS. VIMS, which is similar to motion sickness, is usually recognized as simply being a minor annoyance from which those being affected would recover in the short term. However, some people experiencing this sickness suffer from vomiting or ataxia, and thus, are incapacitated.

Yet, the ambitious production of moving images and the use of those images should not be hindered by considerations to reduce VIMS. Major factors causing VIMS are considered to be visual motion of various kinds in moving image. In addition, visual motion in moving images conveys various types of information, for example, the psychology of characters captured by camera work producing various types of visual motion. For moving images shown to the public and those produced by professional staff, VIMS is presumed to be carefully considered based on empirical knowledge. Besides, adventurous trials can sometimes be necessary to drive forward ambitious moving image production and the use of those images. Moreover, in the absence of empirical knowledge, the uncharted territory of visual effects can come into existence through technical innovations. Although image safety is naturally important, these progressive approaches should not be fully restrained. The issue can be addressed by advancing moving image technology based on an understanding of the characteristics of VIMS. Thus, it is highly important to accumulate scientific knowledge on VIMS. This will encourage attempts to ambitiously produce moving images while considering image safety, which can be expected to lead to further development in the effective use of moving images.

With a view to international standardization for reducing the incidence of VIMS, this document attempts to summarize the scientific knowledge of VIMS by presenting an effective procedure for developing an advanced understanding of VIMS. This is achieved from the viewpoint of empirical knowledge on VIMS obtained during the production of moving images. This document categorizes related scientific knowledge on the ergonomic characteristics of VIMS, and clarifies the conditions under which VIMS can be induced and ways to reduce it. These actions are expected to develop the basis for ambitious moving image production and the use of these images. Furthermore, the work is expected to provide effective and basic data to allow VIMS to be studied together with a discussion of the guidelines focusing on VIMS.

While this document basically focuses on scientific knowledge of VIMS, postural ataxia or disorientation as an aftereffect of visual exposures especially to virtual environment, is another related issue and is even more important from the viewpoint of safety in daily life. However, this document cannot directly deal with the issue because of shortages of scientific reports on it. This should be further examined, and scientific knowledge of the characteristics should be accumulated.

This document does not include any guidelines. Moreover, this document is based on up-to-date data of the ergonomic characteristics of VIMS and can be revised as new scientific data become available.

Ergonomics of human-system interaction —

Part 393: Structured literature review of visually induced motion sickness during watching electronic images

1 Scope

This document gives the scientific summaries of visually induced motion sickness resulting from images presented visually on or by electronic display devices. Electronic displays include flat panel displays, electronic projections on a flat screen, and head-mounted displays.

Different aspects of human-system interaction are covered in other parts of the ISO 9241 series (see Annex A).

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
visually induced motion sickness
VIMS
motion sickness-like symptoms induced by perceived motion within the visual environment, such as when watching movies and screen images of video games

Note 1 to entry: The symptoms may include *dizziness* (3.2), *vertigo* (3.3), sweating, odd feelings in the stomach, and nausea which can progress to vomiting.

3.2
dizziness
physical unsteadiness, lack of balance or light-headedness

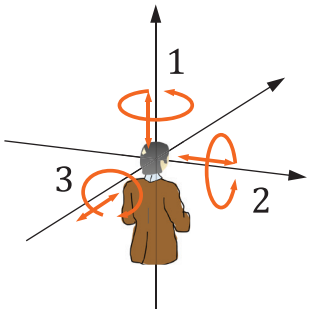
3.3
vertigo
sensation of rotation or movement of oneself (subjective vertigo), or of rotation or movement of one's surroundings (objective vertigo), in any plane, caused by diseases of the inner ear, or by disturbances of the vestibular centres or pathways in the central nervous system

3.4
postural ataxia
inability to coordinate voluntary movements for maintaining posture, caused by dysfunction to sensory nerve inputs, motor nerve outputs, or the processing of them

3.5
disorientation
loss of sense of direction, position or relationship with the surroundings

3.6
global image motion
wide spatial range of visual motion composed of different velocities and directions that are systematically aligned in a moving image

Note 1 to entry: There are generally six types of global image motion that correspond to the different types of motion of a camera during the shooting of images. These are rotation around and translation along the pitch, yaw, and roll axes (see Figure 1).



Key
1 yaw
2 pitch
3 roll

Figure 1 — Rotations around and translation along the three axes

3.7
vection
self-motion perception induced by visual motion

Note 1 to entry: Vection can be categorized into two different types: linear vection and circular vection. Liner vection consists of linear self-motion perception, while circular vection consists of circular self-motion perception around either one or several of the yaw, pitch, and roll axes.

3.8
design field of view
design FOV
angular region subtending the active area of a display as designed to be observed from the viewing position

4 Theories of visually induced motion sickness

Although the specific mechanism of VIMS has not been clarified, there are several hypotheses to explain the cause of motion sickness (MS) including VIMS. Major hypotheses of MS are:

1) sensory conflict theory, or sensory rearrangement theory;

2) poison theory; and

3) postural instability theory.

The sensory conflict theory (Reason and Brand, 1975) explains the cause of MS as the mismatch among different types of sensory information, and even within single modalities of this information, such as visual, vestibular, proprioceptive, etc.

The sensory rearrangement theory suggests that sickness occurs when the pattern of sensory information containing signals from multi-modal senses and those within a single modal sense do not match the patterns of those stored in the central nervous system, or CNS, from past experiences. As a modified version of this sensory rearrangement theory, the theory that focuses on sensory mismatch of the subjective vertical is known as subjective vertical theory. The sensory rearrangement theory holds that the severity of sickness increases when the discrepancy between the pattern of sensory information signals and those stored in CNS becomes larger. When we consider and clarify the meaning of "mismatch" among different senses, it leads to the sensory rearrangement theory, which is widely accepted among researchers. In general, the sensory rearrangement theory is often referred to as sensory conflict theory.

The poison theory (Treisman, 1977) is used to explain why MS arises. The idea is that MS was developed collaterally for organisms to survive in the course of evolution. According to the theory, when emesis was established as a reaction to intoxication by poison, organisms developed a process in which dizziness and vertigo, and then postural instability, is induced while the gastrointestinal tract is being emptied by producing mismatch signals among the visual, vestibular, and proprioceptive modalities. Because of this process, emesis is induced without the ingestion of poison by actual mismatch between the different types of sensory information. This theory is interesting but difficult to examine and it generally does not contradict other theories trying to explain the mechanism of VIMS.

The postural instability theory (Riccio and Stoffregen, 1991) explains the cause of MS as the state of postural instability. Organisms try to keep postural stability in accordance with their environment in daily activities. The stable state can be obtained by reduce body fluctuations to the smallest, while remaining fluctuations cannot be fully controlled. According to the theory, sickness occurs when a stable state cannot be obtained. Moreover, the severity of sickness can be determined by the time the body remains in the unstable state. There are various discussions, both from positive and negative sides, on this theory.

5 Measurement of visually induced motion sickness

Measurement methods of VIMS can be mainly categorized as subjective measures of symptoms or physiological recordings including those of autonomic nervous activities. Subjective measures can be basically classified into two categories:

1) evaluation of sickness severity with one axis scale; and

2) evaluations of various symptoms related to the sickness, which are then used to obtain a total score and several sub-scores.

The measurements required to evaluate one value of sickness severity can be obtained in a short time. Then, those measurements can be carried out while participants are exposed to stimuli of VIMS during experiments. These kinds of measurements were proposed by various researchers who used different scales. Thus, it is rather difficult to directly compare the data obtained in different experiments by different researchers. The scales can be different in light of:

a) the number of points of the scale,

b) the level of severity indicated by the largest score, and

c) the kind of symptom levels attributed to each score of the scale.

The number of points on the scale is inconsistent: some of them have 20, and others have 11, 7, 6, and 4. Keshavarz and Hecht (2011a) proposed a fast motion sickness scale (FMS), which is a 20-point rating scale ranging from zero (no sickness at all) to 20 (frank sickness). They examined and found high correlations with the simulator sickness questionnaire (SSQ), total score (r = 0,79) and sub-score (r = 0,83). They also used it in another experiment (Keshavarz and Hecht, 2011b).

There are two different, but comparable, scales adopting 11-point levels of scoring. One is called the misery scale (MISC), which has been used by Bos and his colleagues (Bos et al., 2005; Lubeck et al., 2015; Lubeck et al., 2016). The scale was revised from the one adopted by Wertheim et al. (1998), based