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IN-VEHICLE VIDEO AND MOTION SICKNESS

BRANDON SCHOETTLE
MICHAEL SIVAK

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Brandon Schoettle
Michael Sivak

The University of Michigan
Transportation Research Institute
Ann Arbor, Michigan 48109-2150
U.S.A.

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16. Abstract

This study consisted of a brief literature review of motion sickness and a paper-and-pencil survey that focused on the frequency and severity of motion sickness of respondents' past experiences while viewing video in a moving vehicle. Also included in the survey were questions related to the frequency of installation of in-vehicle video technology, the physical aspects of the video display, and the frequency of viewing video while traveling in a vehicle. Completed paper-and-pencil surveys were obtained for 136 adults and 32 children.

The results indicate that viewing video is less often the cause of motion sickness than is reading. Similarly, viewing video is less often the cause of severe motion sickness than is reading. (However, if one considers only those respondents who do experience motion sickness, then the severity levels for both activities are similar.) Motion sickness while viewing video is less likely to occur for children than for adults. When it does occur, it is less severe in children than adults.

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CONTENTS

BACKGROUND

Basic aspects

Motion sickness (kinetosis) is a condition marked by symptoms of nausea, dizziness, and other physical discomfort. (The primary symptom—nausea—is a Latin word derived from the Greek *nausia*, both meaning "seasickness.") More extreme symptoms can include vertigo and vomiting.

Motion sickness most often results from a sensory conflict between inputs from the visual and vestibular systems. Sudden or continuously variable motion or accelerations (or at times, the lack thereof) can result in motion sickness. The environments in which we experience these circumstances (and the consequent mismatch between visual and vestibular input) can be found in various modes of transportation (boats, aircraft, passenger cars) and in common entertainment and leisure activities (amusement park rides, video games, IMAX theaters).

Viewing video in a moving vehicle provides ample opportunities for mismatch between visual and vestibular inputs. Specifically, the vestibular system signals particular movement in space, but the vision system (which is focused on the display) signals no corresponding motion.

Comprehensive reviews of motion sickness are contained in Reason and Brand (1975), and Benson (2002).

General susceptibility

A survey conducted by Reason (1967) found that 90% of individuals reported having experienced motion sickness at least once in their lifetime. Reason and Graybiel (1969) were able to induce motion sickness in 98% of test subjects. Though both studies demonstrated a wide range of individual sensitivity to sickness-inducing stimuli, they support the notion that motion sickness is a frequent condition in environments that present conflicting visual motion and physical forces on the body of individuals with a functionally-intact vestibular system. Indeed, motion sickness has been described as a "normal response to an abnormal situation" (Hill, 1936). Furthermore, as stated by

Reason and Brand (1975), "under certain extreme provocative conditions, it is the absence rather than the presence of symptoms which is indicative of real pathology, since only those who lack a normally functioning vestibular system are truly immune."

Individual differences in susceptibility

Age

Motion sickness is virtually nonexistent for children less than two years of age and is rare for the elderly (Benson, 2002; Reason and Brand, 1975).

Gender

In general, women are more prone to motion sickness than are men (Benson, 2002; Reason and Brand, 1975). However, female astronauts do not report more frequent motion sickness than do male astronauts (Benson, 2002).

Behavioral styles

Introverted individuals and field-dependent persons appear to be more susceptible to motion sickness than other individuals (Benson, 2002; Reason and Brand, 1975).

Prevention and mitigation of motion sickness

Drugs

Antiemetic drugs (those designed to lessen or eliminate nausea and vomiting) have been developed to specifically address the symptoms associated with motion sickness. The effectiveness of these drugs varies, and there are several disadvantages in using this method for the treatment of motion sickness (Benson, 2002; Golding and Gresty, 2005; Reason and Brand, 1975). The time required for the onset of the beneficial effect can take several minutes to several hours, requiring administration of the drug well before exposure. This presents an additional problem for individuals experiencing only mild or occasional symptoms, as administration of the drug is required before knowing whether symptoms will occur. Undesirable side effects are also common (dry mouth, drowsiness, blurred vision), and some drugs are not well tolerated by children.

Additionally, repeated doses must be administered if exposure to the sickness-inducing environment is prolonged, as the duration of the benefits is generally limited to several hours. This repeated dosing could increase any potential side effects. Scopolamine (hyoscine) has been reported to be one of the more effective drugs for the reduction of motion sickness symptoms. However, many antiemetic drugs have been shown to be no more effective than a placebo for treating motion sickness (Benson, 2002).

Posture

Varying posture can affect the incidence and severity of motion sickness symptoms. Recent research (Smart, Otten, and Stoffregen, 2007; Smart, Stoffregen, and Bardy, 2002) suggests that postural instability is one of the factors that contribute to the overall sensory conflict that underlies motion sickness. Additionally, there is evidence that lateral and fore-aft motion and forces contribute significantly to motion sickness in passenger vehicles (Benson, 2002; Kato and Kitazaki, 2006; Vogel, Kohlhaas, and von Baumgarten, 1982). (However, one study concluded that fore-aft pitch motion contributes twice as much to motion sickness as does lateral roll motion [Atsumi, Tokunaga, Kanamori, Sugawara, Yasuda, and Inagaki, 2002].)

These findings are consistent with the notion that lying down flat and facing up (i.e., supine), generally helps to lessen the effects of motion sickness (Benson, 2002; Golding and Gresty, 2005; Reason and Brand, 1975). Not only does this position modify the main axes of the body relative to the motions and forces of the vehicle, but it may also lead to better overall postural stability, especially for the head. Conversely, the standard vertical seating position found in passenger vehicles is associated with a significantly higher incidence of motion sickness (Benson, 2002; Kato and Kitazaki, 2006). However, postural adjustments are not always possible or practical in passenger vehicles, especially in the case of the driver or when an individual is attempting to view video on a screen that is mounted in a fixed location. If adopting the supine position is not possible, restricting head motion is a good alternative postural adjustment (Kato and Kitazaki, 2006).

Closing the eyes

Given the underlying visual-vestibular conflict that can cause motion sickness, another potential method for reducing or eliminating symptoms is to reduce or eliminate the conflicting stimuli input. Visual input is most easily "turned off" by simply closing one's eyes. If individuals are not able to set their gaze and posture to allow for a clear view of the forward scene and/or peripheral view of the horizon, then closing of the eyes has been shown to be of some benefit for reducing symptoms of motion sickness (Benson, 2002; Griffin and Newman, 2004; Reason and Brand, 1975). It should be noted, though, that this is not the same as restricting one's view. Indeed, research has shown that restricting the outside and/or forward view within a passenger vehicle can actually exacerbate the symptoms of motion sickness (Butler and Griffin, 2006; Griffin and Newman, 2004).

Adaptation

Adaptation over time to the sickness-inducing stimuli has been reported to be one of the most effective methods for the long-term prevention of motion sickness (Benson, 2002; Golding and Gresty, 2005; Reason and Brand, 1975). The process of adaptation involves extended exposure to an environment containing conflicting visual-vestibular stimuli, usually on multiple occasions and over an extended length of time. The main disadvantages to this prevention method are (1) the need for frequent access and exposure to the environment in question and (2) the fact that the individual will continue to experience motion sickness symptoms in the initial period prior to complete adaptation. Though relief is not as immediate when compared to effective drugs or other countermeasures, adaptation generally provides more complete and lasting relief from motion sickness symptoms and has no side effects (Golding and Gresty, 2005).

Display design

Recent research suggests that novel approaches to in-vehicle display design can help reduce the incidence of motion sickness caused by viewing video in passenger vehicles. These approaches include two general strategies for reducing the visual-vestibular conflict. One approach imposes visual stimuli on or around the video screen to mimic the perceived motion and forces of the moving vehicle (Morimoto, Isu, Okumura,

Araki, Kawai, and Masui, 2008). The other method involves controlling the position of displayed images in synchronization with vehicle motions and passenger head motions produced by vehicle acceleration/deceleration, thus providing video that appears to be stabilized in relation to the movement of the vehicle (Kato and Kitazaki, 2006; 2008). Both approaches were found to be reasonably effective, with each study reporting reductions in motion sickness symptoms to levels below those reported when viewing standard video screens. Furthermore, Morimoto, Isu, Okumura, Araki, Kawai, and Masui (2008) showed improvements in motion sickness to levels approximately equal to the control condition (i.e., no video viewing task).

Present study

The present study was designed to contribute to our understanding of motion sickness while watching video in moving vehicles. Specifically, the study consisted of a survey that examined the frequency and severity of such motion sickness previously experienced by both adults and children. The survey also included questions related to motion sickness from a comparison activity of reading while in a moving vehicle.

METHOD

Survey instrument

A paper-and-pencil survey was developed to examine several issues related to motion sickness while viewing in-vehicle video. The main issues addressed were as follows:

- frequency of installation of in-vehicle video technology and the physical aspects of the video display,
- frequency of viewing video while traveling in a vehicle, and
- frequency and severity of motion sickness while viewing video, reading, or in general without either viewing video or reading.

There were separate adult and child versions of the survey. Only adults were contacted, and those with children completed both the adult and child versions.

Subjects

Employees of UMTRI and their family members were recruited to participate in the survey. All employees were eligible to participate; experience with in-vehicle video technology or with motion sickness was not required.

Adults (18+ years old) and children were surveyed. Completed surveys were received for 136 adults (69 males and 67 females), and 32 children (18 males and 14 females). The age range for adults was 18 to 76 years old, with a mean of 44. The age range for children was 2 to 16 years old, with a mean of 10. (Children were not surveyed directly. Instead, related adults responded for them.)

For the adults, 44% responded that they wore glasses when watching television or videos, 24% wore contact lenses, and 32% did not use corrective lenses while watching television or videos. The corresponding percentages for children were 25%, 16%, and 59%, respectively.

RESULTS

In-vehicle video installation and usage

Table 1 shows a summary of in-vehicle display technology installations. (The installation questions were included only in the adult version of the survey.) When asked if a DVD player, television, or similar video-viewing screen was installed in at least one of the vehicles that they currently owned or regularly drove, 14% of respondents stated that there was. Of those who had in-vehicle video installed, the most common display was interior roof mounted (79%). The most common size (width) for currently installed screens was 7 to 10 inches (53%).

Table 1
Summary of in-vehicle video installations.

Question		Percentage
Have video technology currently installed in vehicle		14
Location	Back of headrest	5
	Interior roof	79
	Seat back	11
	Other	5
Size	Less than 4 inches	5
	4 inches to less than 7 inches	37
	7 inches to 10 inches	53
	More than 10 inches	5

Table 2 provides a summary of the usage of in-vehicle video screens. Viewing of videos while traveling in a passenger vehicle was much more prevalent for children than for adults, with 81% of children having ever watched video compared to only 34% of adults.

The viewing habits of the two groups also differed in terms of the type of screen that they reported having viewed. Adults reported more frequent experience viewing permanently installed or mounted video screens (76%), while children had the most experience with portable display screens (88%). However, for those who had viewed in-vehicle video, both groups reported relatively high familiarity (50% or greater) with both screen types. (Respondents were allowed to select multiple categories regarding the type(s) of screens they had viewed, so the percentages for this question add up to more than 100%.)

Table 2
Summary of in-vehicle video usage. (The entries are percentages.)

Question		Adults	Children
Ever watched video in a passenger vehicle		34	81
Type	Installed or mounted	76	81
	Portable	50	88
	Other	0	8

Reports of motion sickness with in-vehicle video

Table 3 presents a summary of the frequency and severity of motion sickness experienced while viewing video in passenger vehicles, as well as the display type for which motion sickness was most often experienced. Approximately one-quarter of adults report having experienced motion sickness while viewing video in a vehicle (24%), while half as many children experienced the same problem (12%). "Never" being the most common frequency rating for both groups. "Sometimes" was the most common rating for adults who experienced sickness (9%), while the children's reported motion sickness frequency was distributed equally between "rarely," "sometimes," and "often" (4% for each category).

The most frequent severity rating was "none." "Mild" and "moderate" categories together accounted for 20% of adults and 12% of children who experienced sickness.

Table 3
Summary of motion sickness experienced from in-vehicle video usage.
(The entries are percentages.)

Question		Adults	Children
Ever became motion sick from in-vehicle video		24	12
Frequency of motion sickness	Never	76	88
	Rarely	0	4
	Sometimes	9	4
	Often	7	4
	Usually	4	0
	Always	4	0
Severity of motion sickness	None	76	88
	Mild	9	4
	Moderate	11	8
	Severe	4	0
Screen size when motion sick	Less than 4 inches	0	0
	4 inches to less than 7 inches	53	25
	7 inches to 10 inches	29	50
	More than 10 inches	18	25

The most common screen size associated with motion sickness complaints was 4 to 7 inches for adults (53%) and 7 to 10 inches for children (50%). However, this information should be interpreted with caution because not all respondents were exposed to all sizes of displays (see Table 1).

Reports of motion sickness without viewing in-vehicle video

Tables 4 and 5 provide summaries of the frequency and severity of motion sickness experienced while reading in passenger vehicles, and while not reading or viewing video in passenger vehicles, respectively. The majority of adults reported some degree of motion sickness when reading while traveling in a passenger vehicle (57%), while the majority of children did not (69%). (The percentage for children should be interpreted with caution because some of the children were as young as 2 years of age.) When not reading or viewing in-vehicle video, the majority of both groups reported no symptoms (adults: 61%; children: 72%). For both questions and for both groups, the most common severity rating for those who did experience motion sickness was "mild," with decreasing reports for each increase in severity rating.

Table 4
Summary of motion sickness experienced when reading in passenger vehicles.
(The entries are percentages.)

Question		Adults	Children
Frequency of motion sickness when reading	Never	43	69
	Rarely	15	9
	Sometimes	17	9
	Often	9	3
	Usually	8	6
	Always	9	3
Severity of motion sickness when reading	None	43	69
	Mild	25	22
	Moderate	22	3
	Severe	10	6

Table 5
Summary of motion sickness experienced when not reading or viewing video in passenger vehicles. (The entries are percentages.)

Question		Adults	Children
Frequency of motion sickness when not reading or viewing video	Never	61	72
	Rarely	23	13
	Sometimes	12	6
	Often	2	6
	Usually	3	3
	Always	0	0
Severity of motion sickness when not reading or viewing video	None	61	72
	Mild	29	22
	Moderate	7	6
	Severe	2	0

DISCUSSION

Adults

Frequency of motion sickness

A comparison of the frequency of motion sickness by activity in a moving vehicle is shown in Table 6 *for video-watching adults only*. Therefore, the entries in this table for "reading" and "neither" activities are not identical to those in Tables 4 and 5. (An analogous comment applies to the information in Table 7 to follow.)

Different pictures emerge, depending on the response categories considered. For example, more respondents indicated that they "never" experienced motion sickness when viewing video (76%) than when reading (35%) or when doing neither (57%). However, more respondents used one of the three most frequent categories ("often," "usually," or "always") when viewing video (14%) than when not engaged in either viewing video or reading (6%).

Table 6
Frequency of motion sickness by activity in a moving vehicle.
Responses are for video-watching adults only. (The entries are percentages.)

Rating	Activity		
	Viewing video	Reading	Neither viewing video nor reading
Never	76	35	57
Rarely	0	11	26
Sometimes	9	26	11
Often	6	13	2
Usually	4	6	4
Always	4	9	0

Severity of motion sickness

A comparison of the severity of motion sickness by activity in a moving vehicle is shown in Table 7 *for video-watching adults only*. The two most extreme responses ("moderate" or "severe") were used by 15% of respondents when viewing video. This compares to 39% for reading and 8% for neither activity. The same ordering of severity of motion sickness by activity (reading > viewing video > neither reading nor viewing video) was obtained recently by Morimoto, Isu, Ioku, Asano, Kawai, and Masui (2008).

Table 7
Severity of motion sickness by activity in a moving vehicle.
Responses are for video-watching adults only. (The entries are percentages.)

Rating	Activity		
	Viewing video	Reading	Neither viewing video nor reading
None	76	35	57
Mild	9	26	35
Moderate	11	30	6
Severe	4	9	2

Table 8 presents severity data *for video-watching adults who experienced motion sickness* for each activity. This information indicates that if motion sickness occurred, it was of similar severity for viewing video and reading, and the severity for either activity was greater than when not engaged in either activity.

Table 8
Severity of motion sickness by activity in a moving vehicle, *contingent on experiencing motion sickness*. Responses are for video-watching adults only. (The entries are percentages.)

Rating	Activity		
	Viewing video	Reading	Neither viewing video nor reading
Mild	37	40	81
Moderate	46	46	14
Severe	17	14	5

Children

Frequency of motion sickness

A comparison of the frequency of motion sickness by activity in a moving vehicle is shown in Table 9 *for video-watching children only*. Therefore, the entries in this table for "neither" activity are not identical to those in Table 5. (An analogous comment applies to the information in Table 10 to follow.) Given that the ages of children were as young as 2 years of age, Table 9 does not include "reading" activity.

Table 9
Frequency of motion sickness by activity in a moving vehicle.
Responses are for video-watching children only. (The entries are percentages.)

Rating	Activity	
	Viewing video	Neither viewing video nor reading
Never	88	69
Rarely	4	12
Sometimes	4	8
Often	4	8
Usually	0	4
Always	0	0

As with adults (cf. Table 6), rates of never experiencing motion sickness were higher for children when viewing video (88%) than when not viewing video or reading (69%). However, in contrast to adults, children are less likely to experience motion sickness "often," "usually," or "always" when viewing video (4%) than when not viewing video or reading (12%).

Severity of motion sickness

A comparison of the severity of motion sickness by activity in a moving vehicle is shown in Table 10 *for video-watching children only*. The most extreme response category ("severe") was never applicable to motion sickness associated with either viewing video or with neither viewing video nor reading. The second most extreme response category ("moderate") was equally applicable to both conditions (8%).

Table 10
Severity of motion sickness by activity in a moving vehicle.
Responses are for video-watching children only. (The entries are percentages.)

Rating	Activity	
	Viewing video	Neither viewing video nor reading
None	88	69
Mild	4	23
Moderate	8	8
Severe	0	0

Table 11 presents severity data *for video-watching children who experienced motion sickness* for each activity. This information indicates that if motion sickness occurred, severity was greater when viewing video than when neither viewing video nor reading.

Table 11
Severity of motion sickness by activity in a moving vehicle, *contingent on experiencing motion sickness*. Responses are for video-watching children only. (The entries are percentages.)

Rating	Activity	
	Viewing video	Neither viewing video nor reading
Mild	33	74
Moderate	66	26
Severe	0	0

Exposure

A limitation of the current study is the lack of control for overall exposure to the main conditions discussed in the survey (video viewing, reading, and doing neither). Respondents were asked about their experiences with these activities throughout their lifetime, and we did not attempt to quantify this exposure. Since the widespread use of video in passenger vehicles is a relatively recent trend, past exposure to this activity is likely to be much lower when compared to reading or doing nothing (especially for adults). Additionally, the durations of individual exposures for each activity are unknown.

SUMMARY AND CONCLUSIONS

This study consisted of a brief literature review of motion sickness and a paper-and-pencil survey that focused on the frequency and severity of motion sickness of respondents' past experiences while viewing video in a moving vehicle. Also included in the survey were questions related to the frequency of installation of in-vehicle video technology, the physical aspects of the video display, and the frequency of viewing video while traveling in a vehicle. Completed paper-and-pencil surveys were obtained for 136 adults and 32 children.

The results indicate that viewing video is less often the cause of motion sickness than is reading. Similarly, viewing video is less often the cause of motion sickness than is reading. (However, if one considers only those respondents that do experience motion sickness, then the severity levels for both activities are similar.) Motion sickness while viewing video is less likely to occur for children than for adults. When it does occur, it is less severe in children than adults.

REFERENCES

Atsumi, B., Tokunaga, H., Kanamori, H., Sugawara, T., Yasuda, E., and Inagaki, H. (2002). Evaluation of vehicle motion sickness due to vehicle vibration. *JSAE Review, 23*, 341-346.

Benson, A. J. (2002). Motion sickness. In K. B. Pandolf and R. E. Burr (Eds.), *Medical Aspects of Harsh Environments* (pp. 1048-1083). Washington, D.C.: U.S. Department of the Army, Office of the Surgeon General.

Butler, C. A. and Griffin, M. J. (2006). Motion sickness during fore-and-aft oscillation: Effect of the visual scene. *Aviation, Space, and Environmental Medicine, 77*(12), 1236-1243.

Golding, J. F. and Gresty, M. A. (2005). Motion sickness. *Current Opinion in Neurology, 18*, 29-34.

Griffin, M. J. and Newman, M. M. (2004). Visual field effects on motion sickness in cars. *Aviation, Space, and Environmental Medicine, 75*(9), 739-748.

Kato, K. and Kitazaki, S. (2006). *A study for understanding carsickness based on the sensory conflict theory* (SAE Technical Paper Series No. 2006-01-0096). Warrendale, PA: Society of Automotive Engineers.

Kato, K. and Kitazaki, S. (2008). *Improvement of ease of viewing images on an in-vehicle display and reduction of carsickness* (SAE Technical Paper Series No. 2008-01-0565). Warrendale, PA: Society of Automotive Engineers.

Morimoto, A., Isu, N., Ioku, D., Asano, H., Kawai, A., and Masui, F. (2008). *Effects of reading books and watching movies on inducement of car sickness* (F2008-02-024). Poster session presented at the FISITA 2008 World Automotive Congress, Munich, Germany.

Morimoto, A., Isu, N., Okumura, T., Araki, Y., Kawai, A., and Masui, F. (2008). *Screen design of onboard displays for reducing car sickness* (F2008-02-023). Poster session presented at the FISITA 2008 World Automotive Congress, Munich, Germany.

Reason, J. T. and Brand, J. J. (1975). *Motion sickness*. London: Academic Press.

Smart, J. L., Stoffregen, T. A., and Bardy, B. G. (2002). Visually induced motion sickness predicted by postural instability. *Human Factors, 44*(3), 451-465.

Smart, J. L., Otten, E. W., and Stoffregen, T. A. (2007). It's turtles all the way down: A comparative analysis of visually induced motion sickness. In, *Proceedings of the Human Factors and Ergonomic Society 51st Annual Meeting* (pp. 1631-1634). Baltimore, Maryland.

Vogel, H., Kohlhaas, R., and von Baumgarten, R. J. (1982). Dependence of motion sickness in automobiles on the direction of linear acceleration. *European Journal of Applied Physiology and Occupational Physiology, 48*, 399-405.