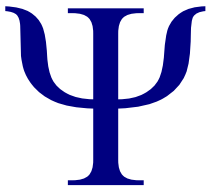
Ausgabe
2025 Nr. 8

Mainz

Experimental Psychology Reports (MEPR)



Psychologisches Institut
Allgemeine Experimentelle Psychologie
Wallstraße 3
55122 Mainz
Telefon +49 6131 39-39266
Fax +49 6131 39-39268
https://experimental.psychologie.uni-mainz.de/

Heiko Hecht, Anna L. Maier, Leonie Hirsch & Oliver Daum

Motion Sickness:

A Methods Primer

A guideline to decide on the most appropriate way to measure motion sickness in the context of human factors research

HEIKO HECHT[1], ANNA L. MAIER[1], LEONIE HIRSCH[1]
& OLIVER DAUM[2]

[1]Psychologisches Institut - Allgemeine Experimentelle Psychologie,
Johannes Gutenberg-Universität, Mainz
[2]Streitkräfteamt der Bundeswehr für angewandte militärpsychologische Forschung

Please cite as: Hecht, H., Maier, A. L., Hirsch, L. & Daum, O. (2025). *Motion sickness: A methods primer.* (Mainz Experimental Psychology Reports Nr. 8). Mainz: Universität Mainz, Abteilung Allgemeine Experimentelle Psychologie.

https://experimental.psychologie.uni-mainz.de/forschungsberichte/

Motion Sickness Measures

There are countless attempts to measure motion sickness (MS). Here we summarize the measures that have been used with some success, and are more or less widely used today. We omit others, which have not been very successful either because the measure was too coarse or for other reasons inappropriate, or because only a few subjects have been used. A notable omission is the pioneering Pensacola Diagnostic Index (PDI, Graybiel et al., 1968), which weighted a set of symptoms but is no longer popular. Most of the other omissions cases consist in brief ratings, such as the 5-point nausea rating by Nurkkala et al. (2012), or the motion sickness severity scale geared toward disease treatment (Czeisler et al., 2023). A review of MS in VR contexts has been provided by Chang et al. (2020).

In the following, we list 19 tests which attempt to measure the subjective experience of motion sickness in all its forms. Most of them are symptom-based and thus require some time to administer. Some consist of simple ratings scales that can be collected while a primary task is carried out. For each test, we report the source such that additional information can easily be looked up. We also provide brief description of the respective test, followed by a quick assessment of its advantages and disadvantages. This assessment is to be taken with a grain of salt as it reflects our theoretical views of what is involved in MS and what the underlying mechanisms might be, which in turn influences how one should best measure it.

May this guide be of service.

Heiko Hecht

Content

1. CSQ

Cybersickness Questionnaire (CSQ)	
Authors	Stone (2017)
Characteristics	Modification of the SSQ; developed to measure symptoms that are clear indicators of cybersickness
Implementation	9 symptom-based items to measure two factors: ▪ Dizziness (items: Headache, Nausea, Dizziness (eyes open), Dizziness (eyes closed), Vertigo) ▪ Difficulty focusing (Items: Eyestrain, Difficulty focusing, Fullness of head, Blurred vision) ▪ Scoring system: 0 (none), 1 (slight), 2 (moderate) (Sevinc & Berkman, 2020)
Validation	Stone (2017): psychometric evaluation of the test Sevinc & Berkman (2020): Psychometric comparison and validation of questionnaire variants (CSQ, SSQ, VRSQ, F-SSQ) with a within-subjects study
Evaluation	**Pros**: ▪ Scoring is easier to administer than the SSQ ▪ Shorter than the SSQ **Cons**: ▪ Scoring method based on item weights (Fig. 1) as in SSQ => complex (Sevinc & Berkman, 2020)
Availability	https://www.proquest.com/dissertations-theses/psychometric-evaluation-simulator-sickness/docview/1918975378/se-2?accountid=14632

Test Administration: CSQ
Calculation of factor scores (Sevinc & Berkman, 2020): [F] = sum (itemScore x itemWeight) [G] = sum (itemScore x itemWeight)

Symptoms in dimensions of simulator sickness and cybersickness scales.

	SSQ			F-SSQ		CSQ		VRSQ	
	Nausea	Oculomotor	Disorientation	Nausea	Oculomotor	Dizziness	Difficulty in focusing	Oculomotor	Disorientation
General discomfort	✓	✓		✓				✓	
Fatigue		✓			✓			✓	
Headache		✓			✓	.50			✓
Eyestrain		✓			✓		.58	✓	
Difficulty focusing		✓	✓		✓		.89	✓	
Increased salivation	✓			✓					
Sweating	✓			✓					
Nausea	✓		✓	✓		.84			
Difficulty concentrating	✓		✓		✓				
Fullness of head			✓		✓		.55		✓
Blurred vision		✓	✓		✓		.81		✓
Dizzy (eyes open)			✓	✓		.89			
Dizzy (eyes closed)			✓	✓		.99			✓
Vertigo			✓	✓		.54			✓
Stomach awareness	✓			✓					
Burping	✓				✓				
	[A]	[B]	[C]	[D]	[E]	[F]	[G]	[H]	[I]

Fig. 1: Symptoms included in different MS and VIMS scales & item weights for CSQ (Sevinc & Berkman, 2020)

2. FMS

Fast **M**otion **S**ickness Scale (**FMS**)	
Authors	Keshavarz & Hecht (2011)
Characteristics	Single verbal rating on a scale from 0 (*no sickness at all*) to 20 (*frank sickness*) with two verbal anchors (Fig. 2) Designed to measure mainly the nausea aspect of VIMS (Keshavarz et al., 2019) ▪ Includes stomach awareness and general discomfort ▪ Participants are instructed to ignore symptoms such as fatigue Provides information about onset, course, severity, and trend of MS (Keshavarz & Hecht, 2011)
Implementation	▪ Immediate verbal response of a single value => application during exposure is possible ▪ If applied frequently: able to record the time course of VIMS (Keshavarz et al., 2019)
Validation	Validated against SSQ (Keshavarz & Hecht, 2011): ▪ High Pearson correlations of peak FMS value: o with SSQ total score (r = .785) o with SSQ nausea subscore (r = .828) o with oculomotor subscore (r = 0.608) o with disorientation subscore (r = 0.795) Reinhard et al. (2017): ▪ FMS was used every minute to measure VIMS in a driving simulator ▪ FMS data showed an increase of FMS-scores with each drive as well as short-term habituation during segments of the drive and long-term adaptation after a week
Evaluation	**Pros**: ▪ Easy to use ▪ Captures the time course of MS if answered at regular intervals during exposure: provides information about onset, course, severity, trend of MS

	▪ No interference with the task ▪ 20-step scale; more finely graded than e. g. SSC ▪ Suitable to measure VIMS and MS **Cons:** ▪ Does not differentiate among different symptoms of VIMS such as dizziness or oculomotor issues (Keshavarz et al., 2019) ▪ Resulting data is not always normally distributed (Keshavarz et al., 2014; Reinhard et al., 2017) ▪ Does not record individual symptoms
Availability	https://doi.org/10.1177/0018720811403736

Test-Administration: FMS

FMS-Instruction (English)

Dear participant,

The following scale was designed to measure your general discomfort, in particular nausea. The experimenter will ask you to verbally report how you feel once every minute. We kindly ask that you respond to this question by choosing a single score on the following 20-point rating scale:

0 ----1----2----3----4----5----6----7----8----9----**10**---11---12---13---14---15---16---17---18---19---**20**

NO SICKNESS AT ALL FRANK SICKNESS

Thus, a score of 0 indicates that you feel perfectly fine, whereas a score of 20 indicates severe nausea to the brink of vomiting.

Please focus in your ratings on currently felt nausea, general discomfort, and stomach problems. It is very important that you respond honestly. You should also note that any additional feelings, such as fatigue, boredom, excitement, nervousness etc., should not influence your rating.

If you have any questions, please ask the experimenter now.

Fig. 2: FMS (Keshavarz & Hecht, 2011)

3. FMS-D

Fast **M**otion **S**ickness Scale - **D**izziness (**FMS-D**)	
Authors	Kaufeld, Mundt, Forst & Hecht (2022)
Characteristics	▪ Single verbal rating on a scale from 0 (*no diziness at all*) to 20 (*extreme dizziness*) (Fig. 3) ▪ Modification of the FMS for measuring symptoms of dizziness as an aspect of VIMS (Kaufeld et al., 2022)
Implementation	▪ Immediate verbal response; single value => application during exposure is possible ▪ If applied frequently: able to record the time course of VIMS
Validation	Kaufeld et al. (2022): ▪ During exposure to augmented reality devices: FMS-D correlated most highly with the disorientation subscale of the SSQ (r = .734); whereas FMS correlated most highly with nausea subscale of the SSQ (r = .769) ▪ Further correlations between FMS/ FMS-D and other subscales of the SSQ as well as SSQ total score (r = .543 - .764)
Evaluation	**Pros**: ▪ Easy to use ▪ Captures time course of MS if answered at regular intervals during exposure ▪ No interference with the task ▪ 20-step scale; more finely graded than e.g. SSC **Cons:** ▪ Resulting data may not be normally distributed ▪ Does not record individual symptoms
Availability	https://doi.org/10.1016/j.displa.2022.102283

Test-Administration: FMS-D

FMS-D Dizziness

The following scale is intended to measure your dizziness. The experimenter will ask you to verbally report how you feel once every minute. We kindly ask that you respond to this question by choosing a single score on the following 20-point rating scale:

0 ----1----2----3----4----5----6----7----8----9----10---11---12---13---14---15---16---17---18---19---20

NOT DIZZY AT ALL EXTREME DIZZINESS

Thus, a score of 0 indicates that you feel perfectly fine, whereas a score of 20 indicates severe dizziness on the brink of vertigo and falling.

Please focus in your ratings on currently felt dizziness and vertigo. It is very important that you respond honestly. You should also note that any additional feelings, such as fatigue, boredom, excitement, nervousness, nausea etc., should not influence your rating.

FMS-D Schwindel (Dizziness)

Die folgende Skala wurde entwickelt um ihr Wohlbefinden (im Speziellen Schwindelgefühl) zu messen. Der Versuchsleiter wird Sie jede Minute fragen, wie Sie sich im Augenblick fühlen. Bitte geben Sie dabei auf der folgenden Skala von 0 – 20 an, wie Sie sich zu diesem Zeitpunkt fühlen:

0 ----1----2----3----4----5----6----7----8----9----10---11---12---13---14---15---16---17---18---19---20
KEIN SCHWINDEL EXTREM STARKER SCHWINDEL

Ein Wert von 0 bedeutet dabei, dass es Ihnen sehr gut geht und Sie keine Beschwerden haben, während ein Wert von 20 bedeutet, dass Sie sich extrem schwindelig fühlen und sich festhalten oder hinlegen müssen.

Bitte konzentrieren Sie sich bei Ihrer Angabe auf Schwindel und Gleichgewichtsstörungen. Es ist sehr wichtig, dass Sie ehrlich auf diese Frage antworten. Bitte ignorieren Sie bei Ihrer Bewertung weitere Gefühle wie Müdigkeit, Langeweile, Aufregung, Nervosität, Übelkeit, etc.

Fig. 3: FMS-D English and German Instructions

4. FMS-Oculomotor Discomfort

Fast **M**otion **S**ickness Scale – **O**culumotor Discomfort/Eye Strain (**FMS-O**)	
Authors	Baljan, M., Keshavarz, B., Hecht, H.
Characteristics	▪ Single verbal rating on a scale from 0 (*no eye strain at all*) to 20 (*extreme eye strain*) (Fig. 4) ▪ Modification of the FMS for measuring symptoms of eye strain as an aspect of VIMS
Implementation	▪ Immediate verbal response; single value => application during exposure is possible ▪ If applied frequently: able to record the time course of VIMS
Validation	* Eichhorn, H. (2023)
Evaluation	**Pros**: ▪ Easy to use ▪ Captures the time course of MS-related ocular discomfort if answered at regular intervals during exposure ▪ No interference with the task ▪ 20-step scale; more finely graded than e.g. SSC **Cons:** ▪ Resulting data may not be normally distributed ▪ Further validation and reliability tests to be done

Test-Administration: FMS-O

FMS-O Oculomotor Discomfort / Eye strain

The following scale is intended to measure the strain and exertion of your eyes. The experimenter will ask you to verbally report how your eyes feel once every minute. We kindly ask that you respond to this question by choosing a single score on the following 20-point rating scale:

0 ----1----2----3----4----5----6----7----8----9----10---11---12---13---14---15---16---17---18---19---20
NO EYE STRAIN AT ALL EXTREME EYE STRAIN

Thus, a score of 0 indicates that your eyes feel perfectly calm and relaxed, whereas a score of 20 indicates severe eye strain making it hard to keep them focused or eliciting the urge to close them altogether.

Please focus in your ratings on currently felt strain and exertion only on the eyes and the immediately adjacent facial regions around the eyes. It is very important that you respond honestly. You should also note that any additional feelings, such as dizziness, fatigue, boredom, excitement, nervousness, nausea etc., should not influence your rating.

FMS-O Augenbeanspruchung (Oculomotor Discomfort)

Die folgende Skala wurde entwickelt, um die Angestrengtheit und Beanspruchung Ihrer Augen zu messen. Der Versuchsleiter wird Sie jede Minute fragen, wie sich Ihre Augen im Augenblick anfühlen. Bitte geben Sie dabei auf der folgenden Skala von 0 – 20 an, wie Sie sich zu diesem Zeitpunkt fühlen:

0 ----1----2----3----4----5----6----7----8----9----10---11---12---13---14---15---16---17---18---19---20

KEINE ANSTRENGTUNG DER AUGEN EXTREM STARKE BEANSPRUCHUNG

Ein Wert von 0 bedeutet dabei, dass sich Ihre Augen sehr entspannt anfühlen und Sie keine Beschwerden haben, während ein Wert von 20 bedeutet, dass sich Ihre Augen extrem angestrengt anfühlen, Sie nur noch schwer fokussieren können und Sie die Augen am liebsten schließen würden.

Bitte konzentrieren Sie sich bei Ihrer Angabe nur auf die Augen und die unmittelbar angrenzenden Gesichtsregionen um die Augen herum. Es ist sehr wichtig, dass Sie ehrlich auf diese Frage antworten. Bitte ignorieren Sie bei Ihrer Bewertung weitere Gefühle wie Schwindel, Müdigkeit, Langeweile, Aufregung, Nervosität, Übelkeit, etc.

Fig. 4: FMS-O English and German version

5. MISC

Misery Scale Index (MISC)	
Authors	Bos, Vries, van Emmerik & Groen (2010)
Characteristics	Measures specific symptoms of motion sickness and their progression over time ▪ Includes deterministic assumptions about the sequence of symptoms 11 discrete levels (Fig. 5) from 0 ("*no problems*") to 10 ("*vomiting*") ▪ Each level is anchored to verbal descriptions of specific symptoms ▪ Ordered by consensus on progression over time Early versions: developed to measure motion sickness on ships (Wertheim et al., 1998; Bos et al., 2005)
Implementation	▪ Immediate (verbal) response of a single number
Validation	▪ Subjective feeling of discomfort increases monotonously with levels of MISC => suggests suitability to capture the progression of motion sickness symptoms (de Winkel et al., 2022) ▪ Pairwise comparison between the verbal anchors ("Which is worse?") showed discontinuity in the order of items 5 and 6 (de Winkel et al., 2022; Reuten et al., 2020) o non-linearity did not occur during numerical and verbal magnitude estimates of discomfort as motion sickness was induced => non-linearity may be due to semantic nature of pairwise comparison (de Winkel et al., 2022)
Evaluation	**Pros:** ▪ Stability, robustness (Keshavarz et al., 2014) ▪ Allows tracking moment-by-moment development better than the SSQ (Keshavarz et al., 2014) ▪ Minimally invasive due to immediate verbal response (de Winkel et al., 2022)

	Cons: ▪ Assumption about sequence of the symptoms not proven: e.g. ambiguities regarding the order of items 5 and 6 (Reuten et al., 2020; de Winkel et al., 2022) ▪ Training is required to ensure correct interpretation by participants o for untrained participants: measures overall subjective level of motion sickness rather than presence of specific symptoms => equivalent to e.g. Well-Being scale and FMS scale (de Winkel et al., 2022) ▪ Implies that other symptoms disappear with the onset of nausea ▪ Measures motion sickness as only one variable => possibly more factors of motion sickness exist (de Winkel et al., 2022)
Availability	https://doi.org/10.1016/j.apergo.2009.11.007

Test-Administration: MISC

Misery scale (MISC).

Symptom		score
No problems		0
Uneasiness (no typical symptoms)		1
Dizziness, warmth, headache, stomach awareness, sweating, …	vague	2
	slight	3
	fairly	4
	severe	5
Nausea	slight	6
	fairly	7
	severe	8
	retching	9
Vomiting		10

Fig. 5: MISC (Bos et al., 2010)

6. MMQ

Mild **M**otion **Q**uestionnaire	
Authors	Lawson, Kass, Muth, Sommers & Guzy (2001)
Characteristics	▪ Paper-and-pencil tool to rate adjectives on 5-point Likert scales ▪ Measures sopite syndrome as well as other responses to non-sickening motion ▪ Based on 39 criteria derived from subject reports who had experienced no or mild symptoms ▪ Arranged into 4 dimensions/subscales: Head/Body, Relaxed/Content, Drowsy/Fatigued, Poor concentration/Motivation ▪ Short-form MMQ consisting of 25 Items was proposed by Brill & Neilson (2011)
Validation	Brill, Kass & Lawson (2004): ▪ MMQ scores differed significantly between exposure to stimuli with mild motion and control conditions ▪ Discriminates effectively among very mild symptoms ▪ Positive correlations between MMQ and MSQ
Evaluation	**Pros**: ▪ Allows for complex assessment of subjective well-being **Cons**: ▪ Focuses on sensory rearrangement and may not be appropriate in common situations where substantial MS has to be measured ▪ Time-consuming to administer
Availability	https://www.researchgate.net/publication/287205911

Test-Administration: MMQ

Mild Motion Questionnaire

"During or just after MILD or NON-SICKENING motions, the following words or phrases apply to me…"

	not at all	a little	moderately	fairly strongly	very strongly
1. content / happy	1	2	3	4	5
2. distant	1	2	3	4	5
3. lazy /unmotivated	1	2	3	4	5
4. weak	1	2	3	4	5
5. lethargic / sluggish	1	2	3	4	5
6. sleepy	1	2	3	4	5
7. apathetic	1	2	3	4	5
8. hard to concentrate	1	2	3	4	5
9. irritable / annoyed	1	2	3	4	5
10. quiet / not communicative	1	2	3	4	5
11. disoriented	1	2	3	4	5
12. headache	1	2	3	4	5
13. calm	1	2	3	4	5
14. fatigued	1	2	3	4	5
15. peaceful	1	2	3	4	5
16. (as if) drugged	1	2	3	4	5
17. distracted / preoccupied	1	2	3	4	5
18. light-headed	1	2	3	4	5
19. soothed	1	2	3	4	5
20. uncoordinated	1	2	3	4	5
21. fuzzy-headed / foggy-headed	1	2	3	4	5
22. tired	1	2	3	4	5
23. dizzy	1	2	3	4	5
24. relaxed	1	2	3	4	5
25. off-balance / wobbly	1	2	3	4	5

11

"During or just after MILD or NON-SICKENING motions, the following words or phrases apply to me…"

	not at all	a little	moderately	fairly strongly	very strongly
26. shaky / jittery	1	2	3	4	5
27. comfortable	1	2	3	4	5
28. confused	1	2	3	4	5
29. want to be alone	1	2	3	4	5
30. (as if) in a trance/hypnotized	1	2	3	4	5
31. yawning	1	2	3	4	5
32. stomach awareness	1	2	3	4	5
33. drowsy	1	2	3	4	5
34. blurred vision	1	2	3	4	5
35. floating	1	2	3	4	5
36. hard to keep eyes open	1	2	3	4	5
37. pleasurable	1	2	3	4	5
38. bored	1	2	3	4	5
39. disconnected / detached	1	2	3	4	5

Fig. 6: MMQ (Wallace et al., 2002)

7. MSAQ

Motion **S**ickness **A**ssessment **Q**uestionnaire (**MSAQ**)	
Authors	Gianaros, Muth, Mordkoff, Levine & Stern (2001)
Characteristics	Multi-symptom questionnaire Measures motion sickness on four dimensions (Fig. 7) ▪ gastrointestinal ▪ central ▪ peripheral ▪ sopite-related 16 Items on 10-point rating scales (‘*not at all’* to *‘severely’*)
Implementation	Manual scoring
Validation	▪ Dimensions of the MSAQ are based on dimensions derived and verified by exploratory and confirmatory factor analyses (Gianaros et al., 2001) ▪ Strong correlations with scores from PDI ($r = 0.81$, $p < 0.001$) and a Nausea Profile ($r = 0.92$, $p < 0.001$) => captures overall experience of motion sickness (Graybiel et al., 1968; Gianaros et al., 2001)
Evaluation	**Pros**: ▪ Suitable for capturing both overall experience and distinct dimensions of motion sickness ▪ Strong focus on sopite-related symptoms ▪ Suitable for average motion environments to which a general population is exposed (Gianaros et al., 2001) **Cons**: ▪ Difficult to capture moment-by-moment development of MS over the period of stimulus presentation, or during recovery from MS (Keshavarz et al., 2014) ▪ Modification may be necessary for application in more demanding specialized contexts (de Winkel et al., 2022)
Availability	https://pmc.ncbi.nlm.nih.gov/articles/PMC2910410/

Test-Administration: MSAQ

MOTION SICKNESS ASSESSMENT QUESTIONNAIRE (MSAQ).

Instructions. **Using the scale below, please rate how accurately the following statements describe your experience**

Not at all — Severely

1——2——3——4——5——6——7——8——9

1. I felt sick to my stomach (G)	9. I felt disoriented (C)
2. I felt faint-like (C)	10. I felt tired/fatigued (S)
3. I felt annoyed/irritated (S)	11. I felt nauseated (G)
4. I felt sweaty (P)	12. I felt hot/warm (P)
5. I felt queasy (G)	13. I felt dizzy (C)
6. I felt lightheaded (C)	14. I felt like I was spinning (C)
7. I felt drowsy (S)	15. I felt as if I may vomit (G)
8. I felt clammy/cold sweat (P)	16. I felt uneasy (S)

Note. G; Gastrointestinal; C: Central; P: Peripheral; SR; Sopite-related.

Fig. 7.1: MSAQ (Gianaros et al., 2001)

The overall motion sickness score is obtained by calculating the percentage of total points scored: (sum of points from all items/144) × 100. Subscale scores are obtained by calculating the percent of points scored within each factor: (sum of gastrointestinal items/36) × 100; (sum of central items/45) × 100; (sum of peripheral items/27) × 100; (sum of sopite-related items/36) × 100.

Fig. 7.2: Computation of the MSAQ score (Gianaros et al., 2001)

8. MSSQ

Motion **S**ickness **S**usceptibility **Q**uestionnaire (**MSSQ**)	
Authors	Revised version: Golding (1998) (Original version: Reason & Brand, 1975)
Characteristics	Designed to predict susceptibility to motion sickness by asking about experienced motion sickness for different contexts in the past (Keshavarz et al., 2019) (Fig. 8) ▪ experiences in adulthood (past 10 years) as well as in childhood (before 12 years of age) ▪ 54 items (Golding, 2006)
Implementation	Questionnaire comprising two and a half pages (Golding, 2006)
Validation	Golding's (1998) revised version of the MSSQ: ▪ Reliability: Cronbach's standardized item alpha = 0.86 ▪ Significant correlation between childhood-part and adulthood-part: r =0.65 ▪ Split-half reliability of 0.77 ▪ Predictive Validity for motion sickness tolerance: r = 0.45 ▪ Average correlation with objective measures of motion sickness tolerance: r = 0.45 ▪ Significant correlations with other sources of nausea/ vomiting within the past year: r= 0.3; migraine was most important for this association ▪ Significant correlations between MSSQ scores and chemotherapy-induced nausea/vomiting
Evaluation	**Pros:** ▪ Revised version: easy to understand and to complete (Golding, 1998) ▪ Includes the history of motion sickness of an individual as a child and as an adult (Keshavarz et al., 2019) ▪ Revised version: simplified scoring system (Fig. 9), results correlate with the original complicated scoring system almost perfectly (Golding, 1998) ▪ Existing adult reference norms (Golding, 1998)

	Cons: ▪ Original version: participants had difficulties to complete the test without explanation (Golding, 1998) ▪ Not designed to predict VIMS (Keshavarz et al., 2019) ▪ Original version: complicated scoring system ▪ Suitable to predict motion sensitivity but less suitable to identify motion-resistant individuals (Golding, 1998) ▪ relatively long
Availability	Golding (1998): doi:10.1016/S0361-9230(98)00091-4

Test-Administration: MSSQ

MOTION SICKNESS SUSCEPTIBILITY QUESTIONNAIRE

This questionnaire is designed to find out how susceptible to motion sickness you are and what sorts of motion are most effective in causing that sickness. Sickness here means feeling queasy or nauseated or actually vomiting.
After some background questions, the questionnaire consists of two sections:
Section A is concerned with your **childhood** experiences of travel and motion sickness, that is, before the age of 12 years.
Section B is concerned with your experiences of travel and motion sickness **over the last 10 years**.
The correct way to answer each question is explained in the body of the questionnaire. It is important that you answer every question.
Thank you for your help.

Background Questions

1. Please State Your Age _____ Years

2. Please State Your Sex (tick box) Male [ ] 1 Female [ ] 2

3. Please State Your Current Occupation _____

4. Do you regard yourself as susceptible to motion sickness? (tick box)

Not at all [ ] 0 Slightly [ ] 1 Moderately [ ] 2 Very much so [ ] 3

Fig. 8.1: Items of the MSSQ (Golding, 1998)

5. As a **Child (before age 12),** how often you **Travelled or Experienced** (tick boxes):

	Never	1 to 4 trips	5 to 10 trips	11 or more trips
Cars				
Buses or Coaches				
Trains				
Aircraft				
Small Boats				
Ships, e.g. Channel Ferries				
Swings				
Roundabouts: playgrounds				
Big Dippers, Funfair Rides				
	0	1	2	3

6. As a **Child (before age 12),** how often you **Felt Sick or Nauseated** (tick boxes):

	Never	Rarely	Sometimes	Frequently	Always
Cars					
Buses or Coaches					
Trains					
Aircraft					
Small Boats					
Ships, e.g. Channel Ferries					
Swings					
Roundabouts: playgrounds					
Big Dippers, Funfair Rides					
	0	1	2	3	4

7. As a **Child (before age 12),** how often you **Vomited** (tick boxes):

	Never	Rarely	Sometimes	Frequently	Always
Cars					
Buses or Coaches					
Trains					
Aircraft					
Small Boats					
Ships, e.g. Channel Ferries					
Swings					
Roundabouts: playgrounds					
Big Dippers, Funfair Rides					
	0	1	2	3	4

Fig. 8.2: Items of the MSSQ (Golding, 1998)

Section B: **Your Experience over the Last 10 Years (approximately).**

For each of the following types of transport or entertainment please indicate:

8. Over the **last 10 years,** how often you **Travelled** or **Experienced** (tick boxes):

	Never	1 to 4 trips	5 to 10 trips	11 or more trips
Cars				
Buses or Coaches				
Trains				
Aircraft				
Small Boats				
Ships, e.g. Channel Ferries				
Swings				
Roundabouts: playgrounds				
Big Dippers, Funfair Rides				
	0	1	2	3

9. Over the **last 10 years,** how often you **Felt Sick** or **Nauseated** (tick boxes):

	Never	Rarely	Sometimes	Frequently	Always
Cars					
Buses or Coaches					
Trains					
Aircraft					
Small Boats					
Ships, e.g. Channel Ferries					
Swings					
Roundabouts: playgrounds					
Big Dippers, Funfair Rides					
	0	1	2	3	4

10. Over the **last 10 years,** how often you **Vomited** (tick boxes):

	Never	Rarely	Sometimes	Frequently	Always
Cars					
Buses or Coaches					
Trains					
Aircraft					
Small Boats					
Ships, e.g. Channel Ferries					
Swings					
Roundabouts: playgrounds					
Big Dippers, Funfair Rides					
	0	1	2	3	4

Fig. 8.3: Items of the MSSQ (Golding, 1998)

MSSQ (REVISED) SIMPLIFIED SCORING METHOD BY HAND

For Section A (Child)

In Q5 score the number of types of transportation experienced at least once (i.e., maximum is 9).
Total the sickness scores for each mode of transportation in Q6 and in Q7 (use the 0−4 number score key at bottom).

$$\text{MSSQA} = \frac{2.64 \times (\text{total sickness score child}) \times 9}{(\text{number of types experienced as a child})}$$

NB. Where a subject has not experienced any forms of transport a division by zero error occurs. It is not possible to estimate this subject's motion sickness susceptibility in the absence of any relevant motion exposure.

For Section B (Adult)

Repeat as for section A above but using the data from section B, i.e., Q8, Q9, Q10 respectively.

$$\text{MSSQB} = \frac{2.64 \times (\text{total sickness score adult}) \times 9}{(\text{number of types experienced as an adult})}$$

Raw Score

$$\text{MSSQ raw score} = \text{MSSQA} + \text{MSSQB}$$

Percentile Score

See Fig. 1 for percentile conversions.

Fig. 9: Scoring method for the MSSQ Revised (Golding, 1998)

9. MSSQ-Short

Motion **S**ickness **S**usceptibility **Q**uestionnaire – Short Version (**MSSQ-Short**)	
Authors	Golding (2006)
Characteristics	▪ Shorter version of the MSSQ by Golding (1998), development based on item analysis of the MSSQ (Golding, 2006) ▪ 18 items (Fig. 10)
Validation	Golding (2006) ▪ Correlation with MSSQ: r = .93 ▪ Internal reliability: Cronbach's alpha = .87 ▪ Correlation between MSA (child) and MSB (adult): r = .68 to .72
Evaluation	**Pros:** ▪ One third of the length of the original MSSQ **Cons**: ▪ Does not include items measuring VIMS
Availability	http://downloads.bbc.co.uk/scotland/tv/trustme/motion_sickness_susceptibility_questionnaire.pdf

Test-Administration: MSSQ-Short

Motion sickness susceptibility questionnaire short-form (MSSQ-Short)

This questionnaire is designed to find out how susceptible to motion sickness you are, and what sorts of motion are most effective in causing that sickness. Sickness here means feeling queasy or nauseated or actually vomiting

Your childhood experience only (before 12 years of age), for each of the following types of transport or entertainment please indicate

1. **As a child (before age 12),** how often you **felt sick or nauseated** (tick boxes)

	Not Applicable - Never Traveled	Never Felt Sick	Rarely Felt Sick	Sometimes Felt Sick	Frequently Felt Sick
Cars					
Buses or Coaches					
Trains					
Aircraft					
Small Boats					
Ships, e.g. Channel Ferries					
Swings in playgrounds					
Roundabouts in playgrounds					
Big Dippers, Funfair Rides					
	t	0	1	2	3

Your experience over the last 10 years (approximately), for each of the following types of transport or entertainment please indicate

2. **Over the last 10 years,** how often you **felt sick or nauseated** (tick boxes)

	Not Applicable - Never Traveled	Never Felt Sick	Rarely Felt Sick	Sometimes Felt Sick	Frequently Felt Sick
Cars					
Buses or Coaches					
Trains					
Aircraft					
Small Boats					
Ships, e.g. Channel Ferries					
Swings in playgrounds					
Roundabouts in playgrounds					
Big Dippers, Funfair Rides					
	t	0	1	2	3

Fig. 10: MSSQ-Short

Scoring of the MSSQ-Short (Golding, 2006):

- For Part A (Child): MSA = (total sickness score child) · (9)/(9_number of types not experienced as a child)
- For Part B (Adult): MSB = (total sickness score adult) · (9)/(9_number of types not experienced as an adult)
- MSSQ raw score = MSA + MSB

10. MSQ

Motion **S**ickness **Q**uestionnaire (**MSQ**)	
Authors	Kennedy & Graybiel (1965)
Characteristics	Very large multi-symptom questionnaire of Pensacola origin. The first part is filled out by the subject and records MS history. The shorter second part is filled out by the experimenter and contains more than 22 symptoms of motion sickness (boredom, breathing awareness, stomach awareness, vertigo, drowsiness, etc.). ▪ Some items rated on a dichotomous yes/no scale ▪ Some items rated on four-point Likert-scales (*none* to *severe*)
Implementation	Manual scoring
Validation	Predicted performance on the dial test (operating dials in different spatial locations while in a rotating environment (Kennedy & Graybiel, 1965)
Evaluation	**Pros**: ▪ Adopted in many different studies ▪ Foundation for further MS measuring instruments **Cons**: ▪ Lengthy to administer ▪ Mixture of binary choice and 4-point ratings
Availability	https://ntrs.nasa.gov/api/citations/19660006694/downloads/19660006694.pdf

11. MSTT

Motion **S**ickness **T**ask **T**olerance (**MSTT**)	
Authors	Kass et al. (2022) as reported in Kremer et al. (2022)
Characteristics	▪ Simple 10-point rating scale grouped into categories (Fig. 11) ▪ Visually presented on a display; answer is given by typing a number into a number pad ▪ Designed for assessing the impact of motion sickness on the tolerance of a secondary task which is executed in an automated-driving scenario (Kremer et al., 2022)
Validation	Kremer et al. (2022): ▪ Participants executed a secondary reading task in an automated-driving scenario which was realized in a driving simulator ▪ Both MSAQ, which was answered after exposure only, and MSTT, which was answered during exposure as well, showed increased motion sickness scores after exposure than before ▪ MSTT showed continuous increase of motion sickness during exposure
Evaluation	**Pros**: ▪ Very short and easy to use ▪ Can be used during exposure => suitable for capturing time course of motion sickness **Cons**: ▪ Needs to be visually presented
Availability	https://doi.org/10.13140/RG.2.2.13442.76487/2

Test-Administration: MSTT

“How severe are your motion sickness symptoms at this moment?”

Fig. 11: MSTT (Kremer et al., 2022)

12. Nausea Scale

Nausea Scale	
Authors	Lo & So (2001)
Characteristics	Usable for measuring nausea during exposure to a simulation Single verbal rating on a seven-point scale: ▪ 0 – no symptom ▪ 1 – any unpleasant symptom, however slight ▪ 2 – mild unpleasant symptom ▪ 3 – mild nausea ▪ 4 – mild to moderate nausea ▪ 5 – moderate nausea but can continue ▪ 6 – moderate nausea, want to stop
Implementation	▪ Immediate verbal response; single value => application during exposure is possible ▪ If applied frequently: able to record the time course of Nausea
Validation	Lo & So (2001) ▪ Score increased with increasing exposure time to a simulation & correlated with scene oscillation
Evaluation	**Pros**: ▪ Easy to use ▪ Captures time course of nausea if answered at regular intervals during exposure ▪ Includes direct information on when the participant wants to stop the exposure **Cons**: ▪ Too few categories to differentiate and define an abortion criterion
Availability	https://doi.org/10.1016/S0003-6870(00)00059-4

13. RSSQ

Revised **S**imulator **S**ickness **Q**uestionnaire (**RSSQ**)	
Authors	Kim, Parker & Park (2004)
Characteristics	Revised version of the SSQ Designed for measuring simulator sickness (VIMS) Measures VIMS symptoms on four subscales ▪ Disorientation ▪ Oculomotor ▪ Nausea ▪ Strain/Confusion Selection and weighting of the items to capture relative importance of the symptoms based on ratings from 15 experts 24 items rated on 11-point ordinal scales (Fig. 12) ▪ 0 – *nothing*, 10 – *very severe* ▪ items from MSQ, SSQ and additional items Subscale total scores can be calculated (Fig. 13, Fig. 14)
Implementation	To be administered after exposure to virtual simulations
Validation	Kim, Parker & Park (2004) ▪ Comparison between pre-exposure and post-exposure scores (N = 64) ▪ Exposure: driving simulator, presented on a monitor with a duration of 15 to 20 minutes ▪ correlation coefficients with SSQ: r = .70 or greater
Evaluation	**Pros:** ▪ Fewer items than the original SSQ (24 vs. 31) ▪ Additional subscale “Strain/Confusion” that was not included in the SSQ ▪ Additional symptoms that were not included in SSQ ▪ Subjects were drawn from a normal population **Cons**: ▪ Very complicated calculation of the scores per subscale ▪ Difficult to capture moment-by-moment development of VIMS over period of stimulus presentation or recovery from VIMS
Availability	Kim, Parker & Park (2004)

Test-Administration: RSSQ

	Weighted Values for Sub-symptoms based on Specialists			
SYMPTOMS (Before / After RSSQ)	N Nausea	D Disorientation	O Ocular Discomfort	C Strain/ Confusion
1. General discomfort			0.00932	0.00932
2. Fatigue			0.01244	
3. Drowsiness		0.00450		
4. Headache			0.04137	
5. Eye-strain			0.04594	
6. Difficulty focusing		0.04297	0.04297	
7. Increased salivation	0.00602			
8. Sweating	0.01435			0.01435
9. Nausea	0.09195			
10. Diff. concentrating				0.03391
11. Fullness of head		0.02909		
12. Blurred vision			0.03132	
13. Dizzy (EO)		0.06847		
14. Dizzy (EC)		0.05927		
15. Vertigo		0.08426		
16. Visual flashbacks			0.03412	0.03412
17. Awareness of breathing	0.03130			
18. Stomach awareness	0.03228			
19. Confusion				0.01765
20. Burping	0.00622			
21. Vomiting	0.17786			
22. Pallor				0.03572
23. Difficulty equilibrating		0.005716		
24. Muscle stiffness for strain				0.03252
Total	[1]	[2]	[3]	[4]

Score
N=[1]_31.23
D=[2]_33.59
O=[3] _61.12
C=[4] _92.85
TS=([1]+[2]+[3]+[4]) _12.86
Blank is zero

Fig. 12: Symptoms of the RSSQ and their weighted values (Kim, Parker & Park, 2004)

Symptoms	Before VR	After VR	Difference(d_i)
1. General discomfort	1	4	3
2. Fatigue	0	2	2
3. Drowsiness	0	1	1
4. Headache	2	3	1
5. Eye-strain	0	2	2
6. Difficulty focusing	0	0	0
7. Increased salivation	2	0	-2
8. Sweating	1	0	-1
9. Nausea	0	0	0
10. Diff. concentrating	0	1	1
11. Fullness of head	0	1	1
12. Blurred vision	0	2	2
13. Dizzy (EO)	1	2	1
14. Dizzy (EC)	2	2	0
15. Vertigo	0	4	4
16. Visual flashbacks	0	3	3
17. Awareness of breathing	0	1	1
18. Stomach awareness	1	1	0
19. Confusion	0	0	0
20. Burping	0	0	0
21. Vomiting	0	0	0
22. Pallor	0	1	1
23. Difficulty equilibrating	1	1	0
24. Muscle stiffness for strain	0	1	1

Fig. 13: Numerical example of subject`s responses (Kim, Parker & Park, 2004)

Find each factor's $\sum_i w_i d_i$

[1] Total of Nausea = $\sum_i w_i d_i$

= (0_3)+(0_2)+(0_1)+(0_1)+(0_2)+(0_0)+(0.00602_-2)+(0.01435_1)
+(0.09195_0)+(0_1)+(0_1)+(0_2)+(0_1)+(0_0)+(0_4)+(0_3)+(0.03130_1)
+(0.03228_0)+(0_0)+(0.00622_0)+(0.17786_0)+(0_1)+(0_0)+(0_1)
= 0.04910

[2] Total of Disorientation = $\sum_i w_i d_i$ = 0.4391

[3] Total of Ocular Discomfort = $\sum_i w_i d_i$ = 0.35109

[4] Total of Strain/Confusion = $\sum_i w_i d_i$ = 0.21812

Calculate each subscale by multiplying $\sum w_i d_i$ with standardized coefficient C_j

Nausea = [1] _ 31.23 = 0.154
Disorientation = [2] _ 33.59 = 14.75
Ocular Discomfort = [3] _ 61.12 = 21.46
Strain/Confusion = [4] _ 92.85 = 20.25

Calculate Total score by multiplying $\sum_j \sum_i w_i d_i$ by standardized coefficient C_T

Total score = ([1] + [2] + [3] + [4]) _12.86 = 13.03

Fig. 14: Calculation of Total Score and Subscale Scores (Kim, Parker & Park, 2004)

14. SSC

Short **S**ymptom **C**hecklist (**SSC**)	
Authors	Nichols, Cobb & Wilson (1997)
Characteristics	▪ Short version of the SSQ ▪ Measures VIMS during VR exposure, suitable to assess a sickness profile during exposure ▪ 6 items (two per subscale), ranging from *not at all* to *severe* on five-point scales
Implementation	Short Questionnaire; the total score seems to be mere addition of the ratings per item with a maximal score of 6 x 4 = 24
Validation	Nichols, Cobb & Wilson (1997): ▪ Correlations with SSQ between r = .61 and r = .71
Evaluation	**Pros**: • Short while preserving symptoms • Easy to score **Cons**: ▪ Correlations with SSQ are lower than correlations between SSQ and FMS (Keshavarz & Hecht, 2011)
Availability	https://doi.org/10.1162/pres.1997.6.6.667

15. SSQ

Simulator **S**ickness **Q**uestionnaire (**SSQ**)	
Authors	Kennedy, Lane, Berbaum & Lilienthal (1993) Additional information from: Stanney & Kennedy (1997)
Characteristics	Multi-symptom questionnaire derived from the MSQ Measures VIMS resp. simulator sickness (in distinction to motion-induced sickness) Measures VIMS symptoms on three subscales with overlapping descriptors ▪ Oculomotor ▪ Disorientation ▪ Nausea / Neurovegative (Stanney & Kennedy, 1997) 16 scored items rated on four-point Likert-scales (0 – 3) ▪ Weighting technique for evaluation (unit weights) ▪ Total score (TS) of max. 236 reflects the overall level of discomfort (Stanney & Kennedy, 1997)
Implementation	Computerized or manual scoring (Kennedy et al., 1993)
Validation	Compared to MSQ ▪ Subscales based on factor analysis of data collected with MSQ in simulations (Kennedy et al., 1993) Kennedy et al. (1993): ▪ Iin aviation context (pilot training) over a period of 20-months ▪ No symptoms for more than half of the population, mild to severe symptoms for other half ▪ Settling-in period was observed: relatively high symptom levels in the beginning of the 20-month period followed by flat decrease o => adaptation to simulation takes place Sevinc & Berkman (2020): ▪ High correlations between subscales Disorientation and Dizziness (r = .916) indicating low discriminant validity for these two scales

	▪ No evidence of construct validity in evaluation of cybersickness based on confirmatory factor analysis ▪ Sensitivity: significant effect of stimuli on mean SSQ total score; SSQ-Disorientation component is less sensitive than the VRSQ Disorientation component and the CSQ Dizziness component; SSQ-Nausea scores are highly sensitive to differences between virtual environments
Evaluation	**Pros**: ▪ Considers differences between motion-induced sickness and simulator sickness in particular ▪ Most common tool to measure VIMS (Keshavarz et al., 2014) ▪ suitable for discriminating problem simulators from simulators that have no problems (Kennedy et al., 1993) o higher sensitivity at upper extremes of symptomatology range (Kennedy et al., 1993) ▪ Captures three separate dimensions of VIMS => allows conclusion on where intervention could be needed **Cons**: ▪ Complex factor structure ▪ Very complicated calculation of the scores per subscale to make them comparable with total score (Fig. 15) ▪ Difficult to capture moment-by-moment development of MS over period of stimulus presentation or recovery from MS (Keshavarz et al., 2014) ▪ Subscales are highly correlated => suboptimal for diagnostic use (Kennedy et al., 1993) ▪ No discrimination among simulators without VIMS problems (Kennedy et al., 1993) ▪ Not ideal for measuring VR sickness (Kim et al., 2018) ▪ Does not provide interval-scaled data (Kaufeld et al., 2022) ▪ Development based on data produced by well trained professionals, may not be representative for the general public (Bouchard et al., 2007; Sevinc & Berkman, 2020) => Bouchard et al. (2007) suggested a two factor-solution (Nausea and Oculomotor) to minimize crossloading (F-SSQ)
Availability	https://doi.org/10.1207/s15327108ijap0303_3

Test-Administration: SSQ

Items of the SSQ (Kennedy et al., 1993):

- **Nausea**: general discomfort, increased salivation, sweating, nausea, difficulty concentrating, stomach awareness, burping
- **Oculomotor**: general discomfort, fatigue, headache, eyestrain, difficulty focusing, difficulty concentrating, blurred vision
- **Disorientation**: difficulty focusing, nausea, fullness of head, blurred vision, dizzy (eyes open), dizzy (eyes closed), vertigo

Nausea » : items {1 + 6 + 7 + 8 + 9 + 15 + 16 } Summe x 9.54 (7 items = max. 200.34)

Oculo-motor »: {items 1 + 2 + 3 + 4 + 5 + 10 + 11 } Summe x 7.58 (7 items, max = 195.18)

Dizziess: items {5 + 8 + 10 + +11 + 12 + 13 + 14 } x 13.92 (7 items, max = 292.32)

Gesamt = (N + O + D) x 3.74 d. h. Max. = 21 x 3 x 3.74 = 235.62

Min = 0 Max = 236

Fig. 15: Calculation of scores per subscale and total score

16. VIMSSQ

Visually **I**nduced **M**otion **S**ickness **S**usceptibility **Q**uestionnaire (**VIMSSQ**)	
Authors	Keshavarz, Saryazdi, Campos & Golding (2019)
Characteristics	Modification of the MSSQ to predict susceptibility to VIMS specifically Scores based on nausea (exemplified in Fig. 16), headache, fatigue, dizziness, and eyestrain during past experiences with visual devices, total of 67 items ➔ Measures how often these 5 symptoms occurred during the use of 11 visual devices in the past ➔ Scores are generated by assigning a numeric value to each item from 0 (never) to 3 (often), *n/a* = never used/ not applicable ➔ Additional question if any of the symptoms ever stopped the individuum to use or avoid any of the devices
Implementation	Suitable for measuring VIMS
Validation	Keshavarz et al. (2019): ▪ Proof-of-concept study ▪ For nausea aspects of the VIMSSQ: Strong correlations with VIMS measured using the FMS Scale in a simulated driving task (r = .54), correlations for dizziness (r = .36) and for the total VIMSSQ score (r = .44) were found Lukacova et al. (2023) Keshavarz et al. (2023): ▪ Can predict the occurrence of VIMS measured by the SSQ (Keshavarz et al., 2023), especially if combined with questions about tendencies to avoid the offending stimuli (Keshavarz et al., 2023)
Evaluation	**Pros**: ▪ Seems superior to other questionnaires like the MSSQ in predicting VIMS (Keshavarz et al., 2023) **Cons**: ▪ Length, can be overwhelming to participants (Keshavarz et al., 2023) => a short version was proposed by Golding et al. (2021), further studies are needed to compare the two
Availability	https://doi.org/10.1177/1071181319631216

Test-Administration: VIMSSQ

Example of the VIMSSQ

*How often have you experienced **NAUSEA** when using any of these devices (tick boxes)*	n/a – not used	never	rarely	sometimes	often
2D movie theatre or cinema					
3D movie theatre or cinema					
IMAX theatre					
Smartphones: dynamic content (e.g., movies, games)					
Tablets: dynamic content (e.g., movies, games)					
Television					
Head Mounted Display/Virtual Reality Glasses					
Video Games (e.g., console, computer)					
Simulators: stationary platform driving or flight (incl. amusement parks)					
Simulators: moving platform driving or flight (incl. amusement parks)					
Large Public Moving Display Advertising or Information Screens					

Fig. 16: Exemplary item of the VIMSSQ (Keshavarz et al., 2019)

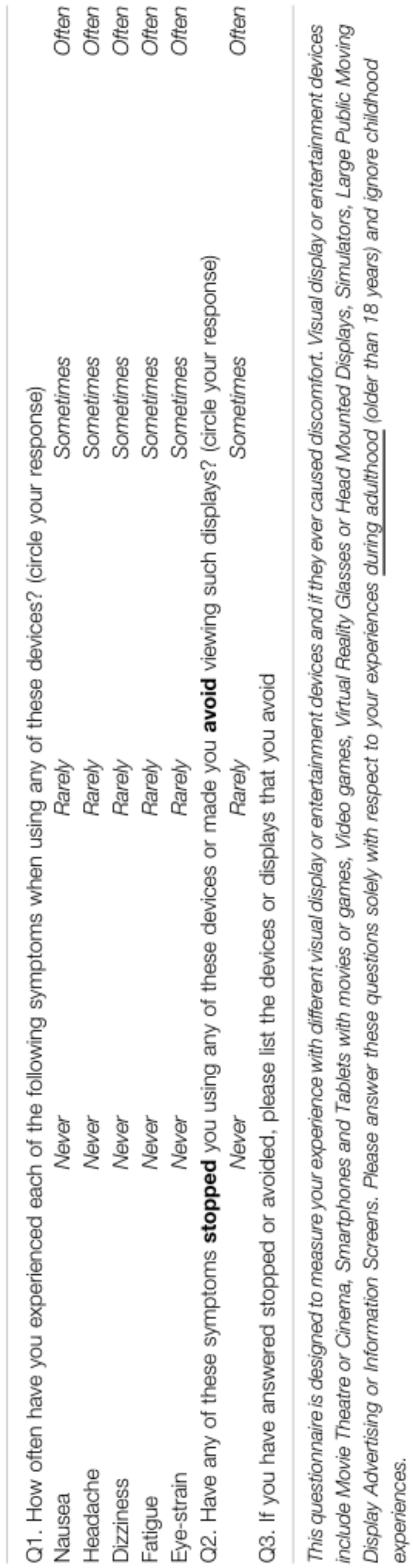
Calculation of each VIMSSQ subscale (Keshavarz et al., 2023):

(*raw subscale score*) * (11) / (11 – *n/a total*)

17. VIMSSQ (short version)

Visually **I**nduced **M**otion **S**ickness **S**usceptibility **Q**uestionnaire (**VIMSSQ**)	
Authors	Golding, Rafiq, & Keshavarz (2021)
Characteristics	Modification of the VIMSSQ 6 items total (Fig. 17) ▪ 5 items about the same five symptoms but for all visual displays together (ranging from 0 = *never* to 3 = *often*) ▪ 1 avoidance item Total score of 0 – 18, higher scores indicate higher susceptibility to VIMS
Implementation	Suitable for measuring VIMS, relatively short
Validation	Golding, Rafiq, & Keshavarz (2021): ▪ Experimental study with 30 participants. They were exposed to a nauseating visual stimulus and filled out a short VIMSSQ as well as the same set of questionnaires used in the study to validate the long version, like MSSQ, syncope, etc. ▪ Explains around 34 % of the variance of VIMS as measured with the original VIMSSQ, increased to 56 % when other questionnaires were added; best used in conjunction with the MSSQ
Evaluation	**Pros**: ▪ Much shorter than original, therefore quick and less overwhelming for participants ▪ Predicts the occurrence of VIMS (measured by the SSQ) (Golding et al., 2021) **Cons**: ▪ No differentiation among visual devices ▪ Further studies with higher sample sizes are needed to figure out the predictive power, as well as studies with varying experimental settings (Golding et al., 2021)
Availability	https://doi.org/10.3389/frvir.2021.576871

Test-Administration: VIMSSQ (short version)



Q1. How often have you experienced each of the following symptoms when using any of these devices? (circle your response)

Nausea	*Never*	*Rarely*	*Sometimes*	*Often*
Headache	*Never*	*Rarely*	*Sometimes*	*Often*
Dizziness	*Never*	*Rarely*	*Sometimes*	*Often*
Fatigue	*Never*	*Rarely*	*Sometimes*	*Often*
Eye-strain	*Never*	*Rarely*	*Sometimes*	*Often*

Q2. Have any of these symptoms **stopped** you using any of these devices or made you **avoid** viewing such displays? (circle your response)

Never *Rarely* *Sometimes* *Often*

Q3. If you have answered stopped or avoided, please list the devices or displays that you avoid

This questionnaire is designed to measure your experience with different visual display or entertainment devices and if they ever caused discomfort. Visual display or entertainment devices include Movie Theatre or Cinema, Smartphones and Tablets with movies or games, Video games, Virtual Reality Glasses or Head Mounted Displays, Simulators, Large Public Moving Display Advertising or Information Screens. Please answer these questions solely with respect to your experiences <u>during adulthood</u> (older than 18 years) and ignore childhood experiences.

Fig. 17: Items of the VIMSSQ's short version (Golding et al., 2021)

18. VRSQ

Virtual **R**eality **S**ickness **Q**uestionnaire (**VRSQ**)	
Authors	Kim, Park, Choi & Choe (2018)
Characteristics	Modification of the SSQ, designed to specifically measure VR sickness, uses the same 4-point rating scale but is limited to 9 Items (Fig. 18) resp. 9 symptoms, then combined into two components (Kim et al., 2018): ▪ Oculomotor component ▪ Disorientation component
Implementation	Comparable to SSQ
Validation	▪ Exploratory and confirmatory factor analyses were used to modify the SSQ Kim et al., 2018: ▪ Target selection tasks with VR headsets ▪ high correlations with SSQ Kourtesis et al., 2023: ▪ memory and psychomotor tasks with VR headsets
Evaluation	**Pros**: ▪ Faster and more efficient than SSQ (Kim et al., 2018) ▪ More suitable for VR environment than SSQ (Kim et al., 2018) ▪ Simpler scoring method than SSQ (Sevinc & Berkman, 2020) **Cons**: ▪ Does not include a nausea component, no sufficient explanation for this exclusion, further research is needed (Kim et al., 2018) ▪ Lack of participants and constrained tasks in the study by Kim et al. (2018)
Availability	https://doi.org/10.1016/j.apergo.2017.12.016

Test-Administration: VRSQ

Virtual reality sickness questionnaire (VRSQ).

VRSQ symptom	Oculomotor	Disorientation
1. General discomfort	O	
2. Fatigue	O	
3. Eyestrain	O	
4. Difficulty focusing	O	
5. Headache		O
6. Fullness of head		O
7. Blurred vision		O
8. Dizzy (eyes closed)		O
9. Vertigo		O
Total	[1]	[2]

Fig. 18: Items of the VRSQ (Kim et al., 2018)

Computation score of VRSQ.

SSQ components	Computation
Oculomotor	([1]/12)*100
Disorientation	([2]/15)*100
Total	(Oculomotor score + Disorientation score)/2

Fig. 19: Computation of the VRSQ-score (Kim et al., 2018)

19. CSQ-VR

Cyber**S**ickness in **VR Q**uestionnaire (**CSQ-VR**)	
Authors	Kourtesis et al. (2023)
Characteristics	Based on VR-specific tests (VRISE and VRNQ) (Somrak et al., 2021) 6 Items (Fig. 20) ▪ Nausea (2 items) ▪ Vestibular component (2 items) ▪ Oculomotor component (2 items)
Implementation	Paper & pencil or computerized
Validation	▪ Internal consistency comparable to SSQ ranging from .7 to .9 (Cronbach's α) ▪ According to Kourtesis et al., 2023: correlation with SSQ subscales between .5 and .8
Evaluation	**Pros**: ▪ Faster and more efficient than SSQ ▪ More suitable for VR environment than SSQ ▪ Simpler scoring method than SSQ **Cons**: ▪ Likert scales from 1-7 partially redundant ▪ Dizziness scored as an aspect of nausea, and fatigue as an aspect of oculomotor strain
Availability	https://osf.io/4w9cs

Test-Administration: CSQ-VR

CyberSickness in Virtual Reality Questionnaire (CSQ-VR)

A brief tool for evaluating the Virtual Reality Induced Symptoms and Effects (VRISE)

Please, from 1 to 7, **circle** the response that better corresponds to the presence and intensity of the symptom.

Nausea A: Do you experience nausea (e.g., stomach pain, acid reflux, or tension to vomit)?

1	2	3	4	5	6	7
Absent Feeling	Very Mild Feeling	Mild Feeling	Moderate Feeling	Intense Feeling	Very Intense Feeling	Extreme Feeling

Please write below any additional comments relevant to the question above:

Further items with the same scales:

Vestibular A: Do you experience disorientation (e. g. spatial confusion or vertigo)?

Vestibular B: Do you experience postural instability (i. e. imbalance)?

Oculomotor A: Do you experience a visually induced fatigue (e. g. feeling of tiredness or sleepiness)?

Oculomotor B: Do you experience a visually induced discomfort (e. g. eyestrain, blurred vision, or headache)?

Fig. 20: Items of the CSQ-VR (Kourtesis et al., 2023)

Category	Symptom	Symptom Intensity	Category Score
Nausea	Nausea (Nausea A)		
	Dizziness (Nausea B)		
Vestibular	Disorientation (Vestibular A)		
	Imbalance (Vestibular B)		
Oculomotor	Fatigue (Oculomotor A)		
	Discomfort (Oculomotor B)		
CSQ-VR Score =			

Symptom Intensity = the score provided by the responder.

Category Score = Score A + Score B

CSQ-VR Score = Nausea score + Vestibular score + Oculomotor score

Fig. 21: Computation of the CSQ-VR-score (Kourtesis et al., 2023)

References

Bos, J. E., MacKinnon, S. N., & Patterson, A. (2005). Motion sickness symptoms in a ship motion simulator: effects of inside, outside, and no view. *Aviation, Space, and Environmental Medicine*, *76*(12), 1111-1118.

Bos, J. E., Vries, S. C. de, van Emmerik, M. L., & Groen, E. L. (2010). The effect of internal and external fields of view on visually induced motion sickness. *Applied Ergonomics*, *41*(4), 516–521. https://doi.org/10.1016/j.apergo.2009.11.007

Bouchard, S., Robillard, G., & Renaud, P. (2007). Revising the factor structure of the Simulator Sickness Questionnaire. *Annual Review of Cybertherapy and Telemedicine*, *5*(Summer), 128-137.

Brill, J. C., Kass, S. J., & Lawson, B. D. (2004). Mild Motion Questionnaire (MMQ): Further evidence of construct validity. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *48*(21), 2503–2507. https://doi.org/10.1177/154193120404802113

Brill, J. C., & Neilson, B. N. (2011). A factor-analytical perspective of sopite syndrome assessment in aerospace systems. *16th International Symposium on Aviation Psychology*, 369-374. https://corescholar.libraries.wright.edu/isap_2011/53

Chang, E., Kim, H. T., & Yoo, B. (2020). Virtual reality sickness: a review of causes and measurements. *International Journal of Human–Computer Interaction*, *36*(17), 1658-1682.

Czeisler, M. É., Pruski, J. M., Wang, P., Wang, J., Xiao, C., Polymeropoulos, M. H., & Polymeropoulos, V. M. (2023). Validation of the motion sickness severity scale: Secondary analysis of a randomized, double-blind, placebo-controlled study of a treatment for motion sickness. *Plos One*, *18*(1), e0280058.

de Winkel, K. N. de, Irmak, T., Kotian, V., Pool, D. M., & Happee, R. (2022). Relating individual motion sickness levels to subjective discomfort ratings. *Experimental Brain Research*, *240*(4), 1231–1240. https://doi.org/10.1007/s00221-022-06334-6

Eichhorn, H. (2023). *Flashing lights – cybersickness and oculomotor stress induced by visual flicker*. Unpublished Bachelor's Thesis, Johannes Gutenberg-University, Mainz, Germany.

Gianaros, P. J., Muth, E. R., Mordkoff, J. T., Levine, M. E., & Stern, R. M. (2001). A Questionnaire for the assessment of the multiple dimensions of motion sickness. *Aviation, Space, and Environmental Medicine*, *72*(2), 115–119.

Golding, J. F. (1998). Motion sickness susceptibility questionnaire revised and its relationship to other forms of sickness. *Brain Research Bulletin*, *47*(5), 507–516. https://doi.org/10.1016/S0361-9230(98)00091-4

Golding, J. F. (2006). Predicting individual differences in motion sickness susceptibility by questionnaire. *Personality and Individual Differences*, *41*(2), 237–248. https://doi.org/10.1016/j.paid.2006.01.012

Golding, J. F., Rafiq, A., & Keshavarz, B. (2021). Predicting individual susceptibility to visually induced motion sickness by questionnaire. *Frontiers in Virtual Reality*, *2*, Article 576871. https://doi.org/10.3389/frvir.2021.576871

Graybiel, A., Wood, C. D., Miller, E. F., & Cramer, D. B. (1968). Diagnostic criteria for grading the severity of acute motion sickness. *Aerospace Medicine*, *39*(5), 453–455.

Kass, C., Tomzig, M., Marberger, C., Schulz, M., Alt, P., Horn, S., Teicht, M. & Engeln, A. (2022). *Short assessment scale to assess motion sickness in automated driving: Motion Sickness Task Tolerance (MSTT) Scale.* Unpublished Report. https://doi.org/10.13140/RG.2.2.13442.76487/2

Kaufeld, M., Mundt, M., Forst, S., & Hecht, H. (2022). Optical see-through augmented reality can induce severe motion sickness. *Displays*, *74*, 102283. https://doi.org/10.1016/j.displa.2022.102283

Kennedy, R. S., & Graybiel, A. (1965). *The dial test: A standardized procedure for the experimental production of canal sickness symptomatology in a rotating environment*. Subtask 1 Report No. 113, NASA Order No. R-93. Ft. Belvoir: Defense Technical Information Center.

Kennedy, R. S., Lane, N. E., Berbaum, K. S., & Lilienthal, M. G. (1993). Simulator Sickness Questionnaire: An enhanced method for quantifying simulator sickness. *The International Journal of Aviation Psychology*, *3*(3), 203–220. https://doi.org/10.1207/s15327108ijap0303_3

Keshavarz, B., & Hecht, H. (2011). Validating an efficient method to quantify motion sickness. *Human Factors*, *53*(4), 415–426. https://doi.org/10.1177/0018720811403736

Keshavarz, B., Hecht, H., & Lawson, B. D. (2014). Visually induced motion sickness: Causes, characteristics, and countermeasures. In: K. S. Hale, K. M. Stanney (Eds.), *Handbook of Virtual Environments: Design, Implementation, and Applications*. Taylor & Francis, Boca Raton, FL, 647–698.

Keshavarz, B., Saryazdi, R., Campos, J. L., & Golding, J. F. (2019, November). Introducing the VIMSSQ: Measuring susceptibility to visually induced motion sickness. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 63, No. 1, pp. 2267-2271). Sage CA: Los Angeles, CA: SAGE Publications.

Keshavarz, B., Murovec, B., Mohanathas, N., & Golding, J. F. (2023). The Visually Induced Motion Sickness Susceptibility Questionnaire (VIMSSQ): Estimating individual susceptibility to motion sickness-like symptoms when using visual devices. *Human Factors*, *65*(1), 107–124. https://doi.org/10.1177/00187208211008687

Kim, H. K., Park, J., Choi, Y., & Choe, M. (2018). Virtual reality sickness questionnaire (VRSQ): Motion sickness measurement index in a virtual reality environment. *Applied Ergonomics*, *69*, 66–73. https://doi.org/10.1016/j.apergo.2017.12.016

Kim, D. H., Parker, D. E., & Park, M. Y. (2004). *A new procedure for measuring simulator sickness – the RSSQ*. Technical Report R-2004-52. Human Interface Technology Laboratory, University of Washington, Seattle, WA.

Kourtesis, P., Linnell, J., Amir, R., Argelaguet, F., & MacPherson, S. E. (2023). Cybersickness in virtual reality questionnaire (CSQ-VR): A validation and comparison against SSQ and VRSQ. In *Virtual Worlds*, *2(1)*, 16-35. *doi.org/10.3390/virtualworlds2010002*

Kremer, C., Tomzig, M., Merkel, N., & Neukum, A. (2022). Using active seat belt retractions to mitigate motion sickness in automated driving. *Vehicles*, *4*(3), 825–842. https://doi.org/10.3390/vehicles4030046

Lawson, B. D., Kass, S., Muth, E., Sommers, J., & Guzy, L. (2001). Development of a scale to assess signs and symptoms of sopite syndrome in response to mild or nonsickening motion stimuli. Abstracts of the Aerospace Medical Association Annual Scientific Meeting (p. 66)

Lo, W. T., & So, R. H. (2001). Cybersickness in the presence of scene rotational movements along different axes. *Applied Ergonomics*, *32*(1), 1–14. https://doi.org/10.1016/S0003-6870(00)00059-4

Lukacova, I., Keshavarz, B., & Golding, J. F. (2023). Measuring the susceptibility to visually induced motion sickness and its relationship with vertigo, dizziness, migraine, syncope and personality traits. *Experimental Brain Research*, *241*(5), 1381–1391. https://doi.org/10.1007/s00221-023-06603-y

Nichols, S., Cobb , S., Wilson, J. R. (1997). Health and safety implications of virtual environments: Measurement issues. Presence, 6, 667–675.

Nurkkala, V. M., Koskela, K., Kalermo, J., Nevanperä, S., Järvilehto, T., & Honkanen, R. (2012). A method to evaluate temporal appearances of simulator sickness during driving simulation experiments. *Actes INRETS*, 41-9.

Reason, J. T., & Brand, J. J. (1975). *Motion sickness.* Academic Press.

Reinhard, R., Rutrecht, H. M., Hengstenberg, P., Tutulmaz, E., Geissler, B., Hecht, H., & Muttray, A. (2017). The best way to assess visually induced motion sickness in a fixed-base driving simulator. *Transportation Research Part F: Traffic Psychology and Behaviour*, *48*, 74–88. https://doi.org/10.1016/j.trf.2017.05.005

Reuten, A., Bos, J., & Smeets, J. B. (2020). The metrics for measuring motion sickness. In *Driving Simulation Conference Europe 2020 VR proceedings* (pp. 183-186). (Driving Simulation Proceedings; Vol. 2020). Driving Simulation Association. https://proceedings.driving-simulation.org/proceeding/dsc-2020/the-metrics-for-measuring-motion-sickness/

Sevinc, V., & Berkman, M. I. (2020). Psychometric evaluation of Simulator Sickness Questionnaire and its variants as a measure of cybersickness in consumer virtual environments. *Applied Ergonomics*, *82*, 102958. https://doi.org/10.1016/j.apergo.2019.102958

Somrak, A., Pogačnik, M., & Guna, J. (2021). Suitability and comparison of questionnaires assessing virtual reality-induced symptoms and effects and user experience in virtual environments. *Sensors*, *21*(4), 1185.

Stanney, K. M., & Kennedy, R. S. (1997). The psychometrics of cybersickness. *Communications of the ACM*, *40*(8), 66–68. https://doi.org/10.1145/257874.257889

Stone, William Bruce, III. (2017). *Psychometric evaluation of the Simulator Sickness Questionnaire as a measure of cybersickness* (Order No. 10272158). ProQuest Dissertations & Theses Global. (1918975378). https://www.proquest.com/dissertations-theses/psychometric-evaluation-simulator-sickness/docview/1918975378/se-2

Wallace, J. C., Kass, S. J., & Lawson, B. D. (2002). Assessing a specific measure of sopite syndrome: The mild motion questionnaire. *The Naval Aerospace Medical Research Laboratory Technical Report No. 1414*, Pensacola, FL.

Wertheim, A. H., Bos, J. E., & Bles, W. (1998). Contributions of roll and pitch to sea sickness. *Brain Research Bulletin*, *47*(5), 517–524. https://doi.org/10.1016/S0361-9230(98)00098-7