Ego OR Exo: Comparing Visual Perspectives on Guidance Visualisations for Motor Learning

Masterarbeit

vorgelegt von

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Abstract

Motor Learning in Mixed Reality prooved to be good. But view reseach in the influence of the perspective on guidance visualisation. This work proposes a study to investigate this. Task is handling physical load. will enable designers of MR ML systems to base their work on on empirical data.

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1 Introduction

The acquisition of movements is a crucial part of human development. Learning movements empowers to be more efficient, faster and more exact. The capability of enhanced movements enables the learner to survive from the very beginning. The process of learning movements is called Motor Learning. Nowadays, Motor Learning is still crucial. Especially for tasks like sports, arts or the ergonomic handling of physical load.
Most movements we learn by voyeurism and mimicking: watching and trying it out by yourself. Mastering a movement is performed best with an experienced teacher. A teacher is hardly replaceable because of immediate visual, audible and haptic feedback on a performed movement. However, if a teacher is not available, for example, based on the location or economic reasons, other sources can be used to learn movements. For example, YouTube[1], TikTok[2], and other video platforms have become a great source for learning videos with a wide range of purposes. The downside of videos is the two dimensional (2D) experience of a three dimensional (3D) movement. Mixed Reality (MR) can provide this experience in 3D. Furthermore, MR can provide feedback on the performed movement and has the ability for interactions with the virtual guidance visualisation. MR already proved to be a suitable environment for Motor Learning for tasks like dancing [1–5], sports [6, 7], Rehabilitation [**veimprovesml**, 8–11], arts [12–19] and others [20, 21].
In the real world, where the student and teacher are real persons, the student sees the teacher, for example, in front of himself/herself. This perspective is called the exo-centric visual perspective. Nevertheless, if we move from the real world to the virtual world of MR, we are no longer restricted to the exo-centric visual perspective. The teacher can be rendered inside the student's body, allowing the student to see the teacher from an ego-centric perspective. The change from the exo-centric to the ego-centric visual perspective potentially influences Motor Learning, shown by previous research; for example, AR-Arm [12] lets the learner experience the movements from an ego-centric perspective. YouMove [1] teaches dance from an exo-centric perspective. OneBody [18], Light Guide [21], MR Dance Trainer [5], Free Throw Simulator [6], Training Physical skills [7], Sleeve AR [11] and Thai Chi Trainer [19] use both visual perspectives. However, only OneBody, LightGuide and TaiChi Trainer found a difference between the visual perspectives. Furthermore, none of these works investigated how the visual perspective influences the performance of the learner. Another topic where MR could be a valuable helper is the ergonomic conduction of movements while handling physical load [22, 23]. Handling physical load in the correct ergonomic conduct in working routines can prevent injuries in everyday life. However, a kinaesthetics teacher is not always accessible, for example, for economic reasons. The influence of the visual perspective on a virtual guidance visualisation teaching the handling of physical load in mixed reality is sparsely investigated todo: is there a source?. Especially, transitional movements like walking in the ego-centric perspective is left out. The lack of research in the influence of the visual perspective on a virtual guidance visualisation, especially for handling physical loads, shows the necessity of investigations on:

RQ1: How does the visual perspective on a virtual guidance visualisation influence Motor Learning in Virtual Reality environments?

To answer this main research question RQ1, several aspects have to be taken into account: accuracy of movements, transfer of information of how to move, the visual focus of the learner and last but not least, the personal preference of the learner. Therefore, to answer the main research question RQ1, it is necessary to answer the following sub-research questions:

[1]https://www.youtube.com/, accessed 17.2.2021
[2]https://www.tiktok.com/, accessed 17.2.2021

RQ1.1 How does the visual perspective on a virtual guidance visualisation influence movements' accuracy?

RQ1.1.1 How does the visual perspective on a virtual guidance visualisation influence movements' accuracy of the own body?

RQ1.1.2 How does the visual perspective on a virtual guidance visualisation influence the accuracy of handling physical load?

RQ1.1.3 How does the visual perspective on a virtual guidance visualisation influence sub-tasks' accuracy?

RQ1.2 Does the visual perspective on a virtual guidance visualisation influence the transfer of ergonomic principles?

RQ1.3 How does the visual perspective on a virtual guidance visualisation influence the learner's visual focus?

RQ1.4 What is the subjective personal preference of the learner for the visual perspectives?

A detailed discussion of the research questions can be found in 3.2.
The answers to these research questions will enable designers of VR Motor Learning training systems to choose a suitable visual perspective on an empirical basis.

1.1 Outline

This work proposes a study design to answer the research question. To design this study on a solid basis, the theoretical foundations a laid in chapter 2 with a closer look on Motor Learning (section 2.1), visual perspectives (section 2.2) and Mixed Reality (section 2.4). These sections result in the scope and parameters of the study design. Section 2.5 investigates previous works and illustrates the conceptual delimitation of this work from what has already been investigated. Chapter 2 concludes with a research contribution statement, clarifying the Empirical Contribution and Artifact Contribution of this work.
For the proposed study, a system had to be designed to produce data to answer the research questions. This system is called E(x|g)oThe design and and implementation is described in section 3.1 followed by the design of the study itself in section 3.2.
E(x|g)o and the study design have been evaluated in a pilot study. The results of the evaluation are depicted in chapter 4. Furthermore, this chapter suggests improvements in the study design in section 5.2. This work concludes in chapter 5 with an outlook on how E(x|g)o can be enhanced and expanded as well as used for further investigations.

long long label asdad asfiojh aojgf oijgoias gjoasig

2 Motor Learning in Virtual Reality

The aquisition and improvement of movements is called motor learning [24]

2.1 Motor Learning

grundlagen des motor learning

2.2 Visual Perspectives

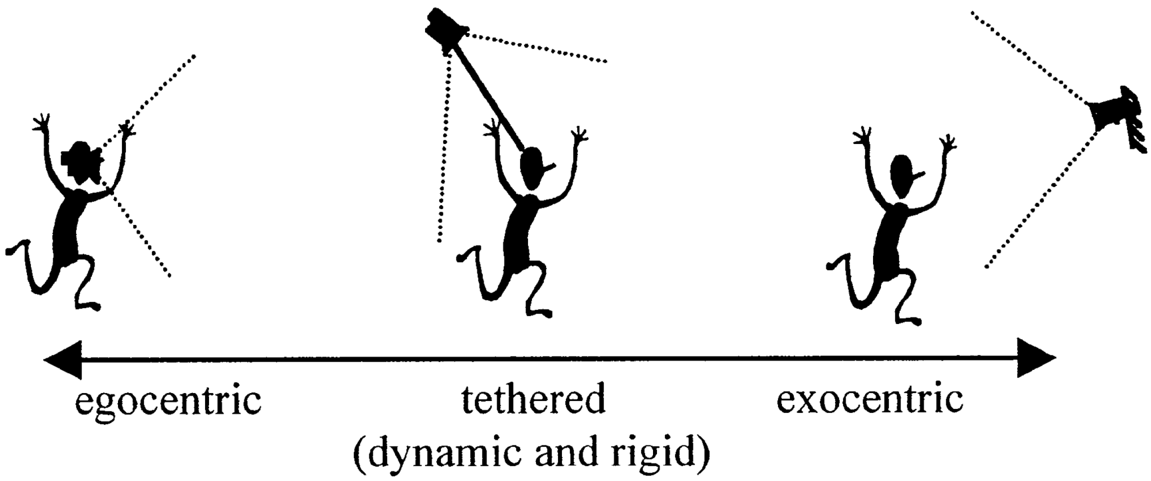

Figure 2.1: Centricity continuum by Wang and Milgram [25]

ego-exo continuum,

2.2.1 measurements for motorlearning?

2.3 Handling Physical Load

manual material handling [26], single: lift lower push pull carry hold, hold out because of confusion with speed mechanic, introduced carry because of variaation and flexibility in task. unit/combined mmh tasks classification.

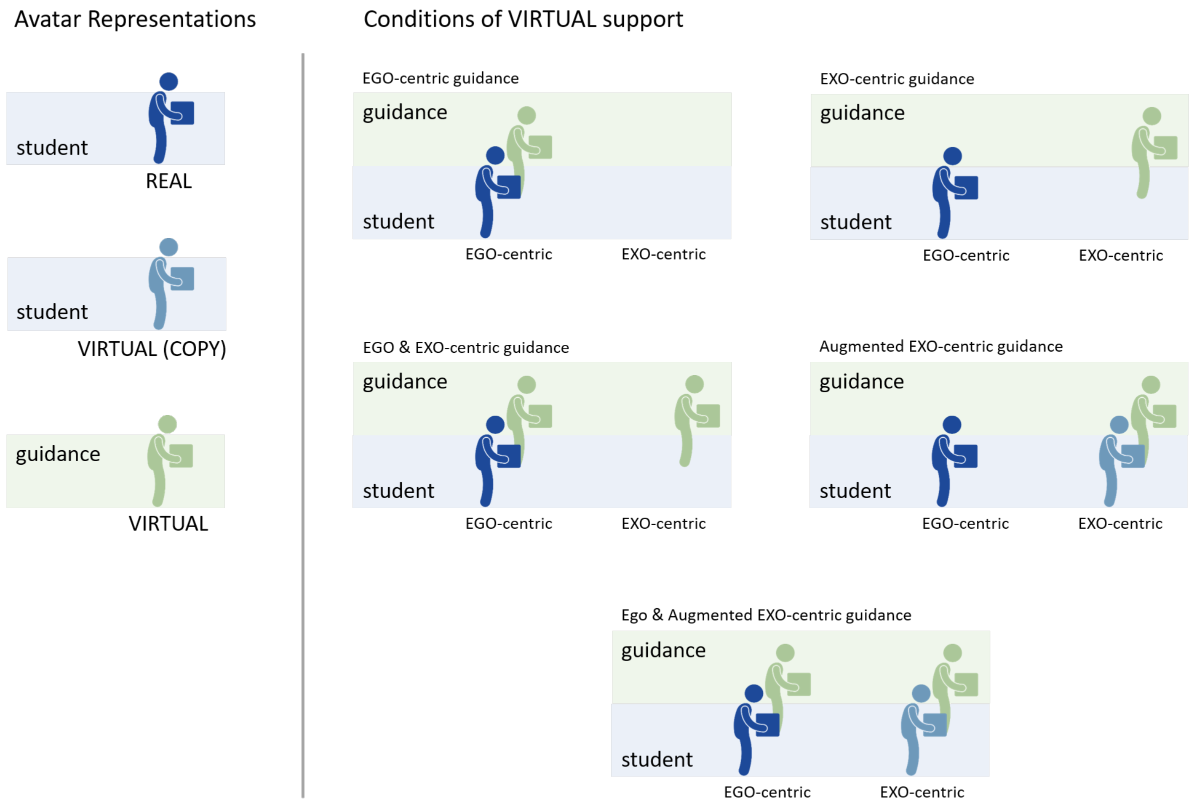

Figure 2.2: Possible perspectives with one real world student and one real world teacher.

baua classification? https://www.baua.de/EN/Topics/Work-design/Physical-workload/Types-of-workload/Types-of-workload$_node.html https://www.baua.de/DE/Themen/Arbeitsgestaltung-im-Betrieb/Gefaehrdungsbeurteilung/$
$Belastung/Heben - Halten - Tragen/Heben - Halten - Tragen_node.html$

2.4 Mixed Reality

argumentation warum VR und nicht AR?

2.5 Related Work: Motor Learning in Virtual Reality

Similar setup [27]

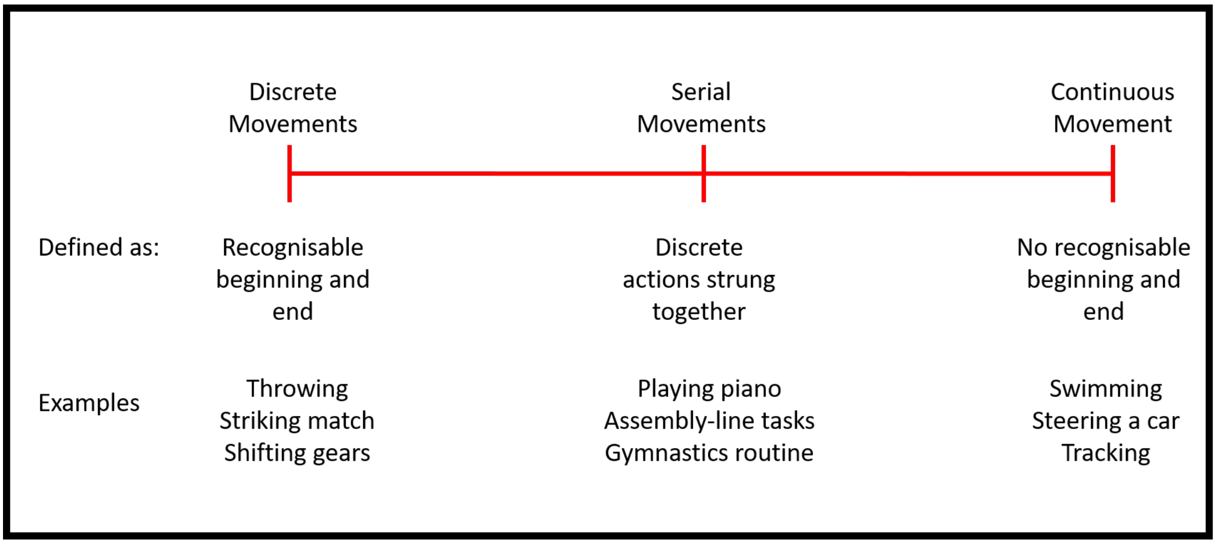

Figure 2.3: Movement classification 1

2.6 Research Contribution Statement

bekannte arbeiten und deren ergebnisse über motor learning in VR

auf basis dieses kapitels wird die studie geformt

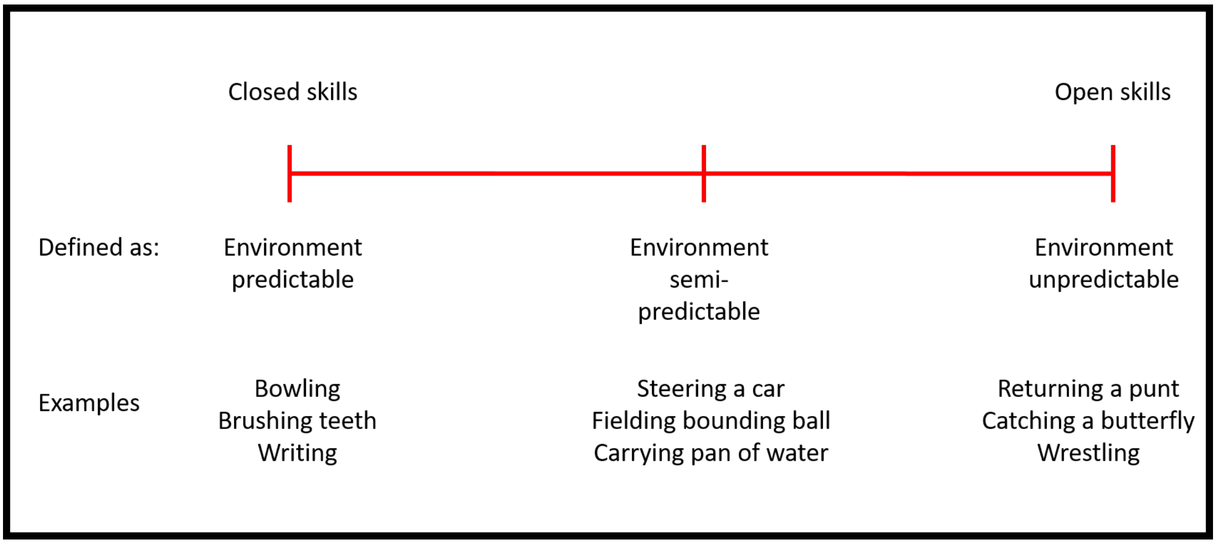

Figure 2.4: Movement classification 2

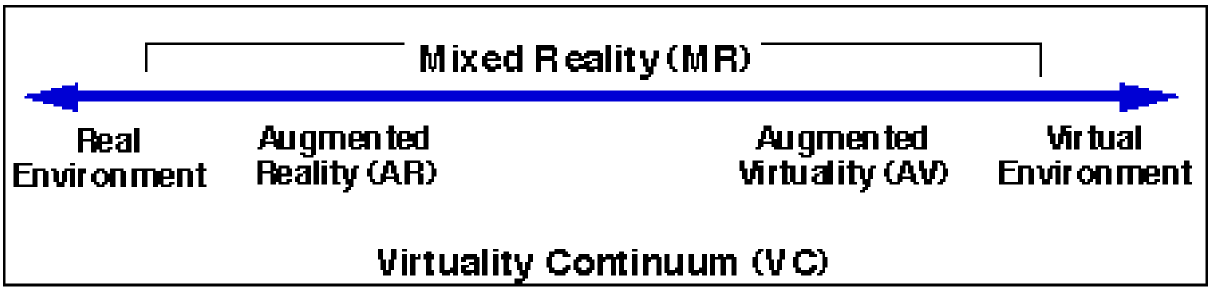

Figure 2.5: Ego-centric / exo-centric continuum by Milgram todo: source

	Tai Chi Trainer	YouMove	VR Dance Trainer	OneBody	LightGuide	Physio@Home
Perspective	Exo-centric, Ego & Augmented Exo-centric	Exo-centric	Exo-centric	Ego-centric, Exo-centric	Ego-centric, Exo-centric	Exo-centric
Task	Tai Chi	Dance (Ballet), abstract	Dance (HipHop)	Martial Arts	Abstract	Shoulder rehab
Guidance Visualisation	hr avatar, wireframe, mimic avatar	Stick figure, mimic avatar	hr figure, mimic avatar	Stick figure, mimic avatar	Indicators, follow/mimic	Indicators
Variables	Perspectives, performance measure	VR/Video, performance	Video/VR, performance	Training method, performance	Visualisations, Perspective, Performance	Visualisation, performance
Results	No difference in performance	VR better than video	VR better than video	Ego better than exo	Ego better than exo	Multi view better than single view

Figure 2.6: Overview seminar evaluation

Ego-centric	**Exo-centric**	**Ego || Exo-centric**
AR-Arm (Han et al. 2016)	MotionMA (Velloso et al. 2013)	OneBody (Hoang et al. 2016)
Just Follow Me (Yang & Kim 2002)	YouMove (Anderson et al. 2013)	LightGuide (Sodhi et al. 2012)
Gohstman (Chinthammit et al. 2014)	VR Dance Trainer (Jacky Chan et al. 2010)	MR Dance Trainer (Hachimura et al. 2004)
Stylo and Handifact (Katzakis et al. 2017)	Physio@Home (Tang et al. 2015)	Free Throw Simulator (Covaci et al. 2014)
GhostHands (Scavo et al. 2015)	OutSide me (Yan et al. 2015)	Training Physical Skill (Kojima et al. 2014)
	e-Learning Martial Arts (Komura et al. 2006)	SleeveAR (Sousa et al. 2016)
	My Tai-Chi Coaches (Han et al. 2017)	Tai Chi Trainer (Chua et al. 2006)
	Performance Training (Chan et al. 2007)	
	RT Gestrue Recognition (Portillo et al. 2008)	
	KinoHaptics (Rajanna et al. 2015)	
	TIKL (Lieberman & Breazeal 2007)	

Dance Sports Rehab Arts Abstract

Figure 2.7: Overview Related Work divided by perspective and task

3 E(x|g)o- Design and Implementation

(15 pages)

3.1 E(x|g)o

Studysetup
frameworks
implementation
perspectives
mechanics
logging
limitations
iterative implementation
formative tests

3.2 Study

tasks
procedure
geplante evaluierung
limitations
bezug zwischen messungen und forschungsfragen
triangulation nutzen wo sinnvoll

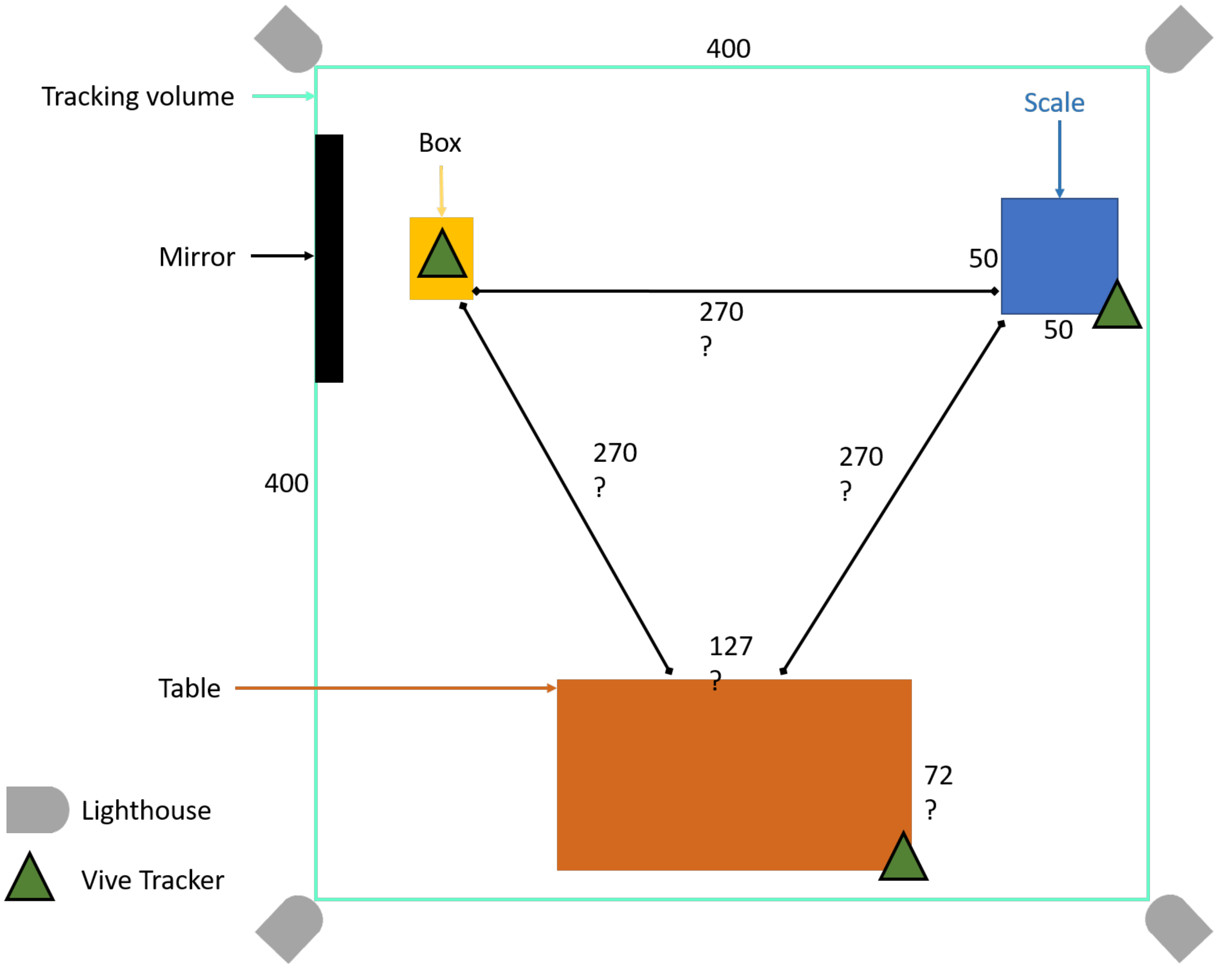

Figure 3.1: study setting

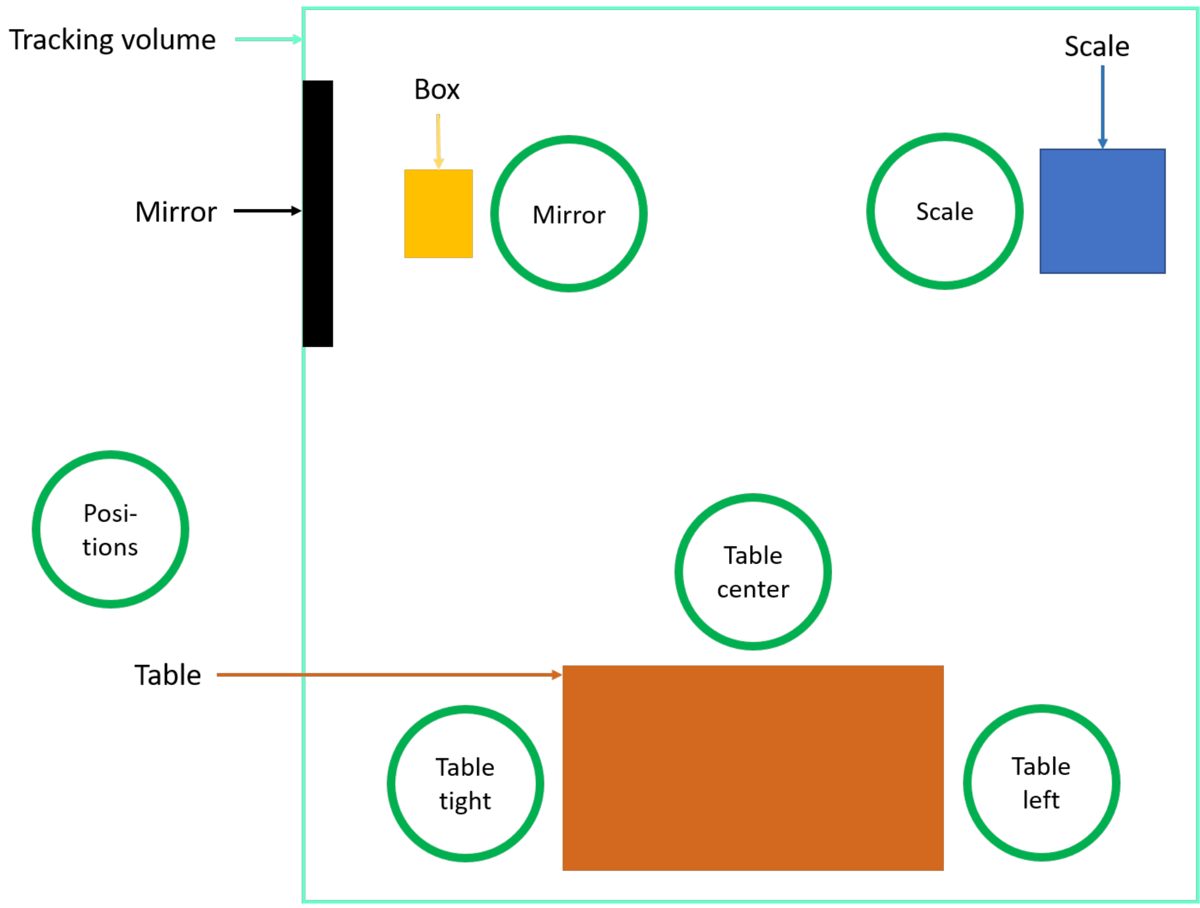

Figure 3.2: tasks

Logging ID	Description	Unit	Research question
Elapsed time	Time since the beginning of the task	Milliseconds	RQ1.1.1-3
Current animation Frame	Current frame of the GV animation	frames	RQ1.1.1-3
Subtask ID	The current sub task performed by L	STID	RQ1.1.3
Hip distance	ED between hip of the GV and the hip L	Meters	RQ1.1.1
Left hand distance	ED between left hand GV and left hand L	Meters	RQ1.1.1
Right hand distance	ED between right hand GV and right hand L	Meters	RQ1.1.1
Left foot distance	ED between left foot GV and left foot L	Meters	RQ1.1.1
Right foot distance	ED between right foot GV and right foot L	Meters	RQ1.1.1
Head distance	ED between head GV and head L	Meters	RQ1.1.1*
Box distance	ED between box GV and box L	Meters	RQ1.1.2
Hip angle	ED between hip of the GV and the hip L	Degrees	RQ1.1.1
Left hand angle	ED between left hand GV and left hand L	Degrees	RQ1.1.1
Right hand angle	ED between right hand GV and right hand L	Degrees	RQ1.1.1
Left foot angle	ED between left foot GV and left foot L	Degrees	RQ1.1.1
Right foot angle	ED between right foot GV and right foot L	Degrees	RQ1.1.1
Head angle	ED between head GV and head L	Degrees	RQ1.1.1*, RQ1.3
Box angle	ED between box GV and box L	Degrees	RQ1.1.2
L spine bend	RM spine bend of L	Degrees	RQ1.2
L foot distance	RM base of L	Meters	RQ1.2
L squat distance	RM squat distance of L	Meters	RQ1.2
L hip-box distance	RM elbows L	Meters	RQ1.2
GV spine bend	RM spine bend of GV	Degrees	RQ1.2
GV foot distance	RM base of GV	Meters	RQ1.2
GV squat distance	RM squat distance of GV	Meters	RQ1.2
GV hip-box distance	RM elbows GV	Meters	RQ1.2
L looking at	The object L is looking at	LAID	RQ1.3
Pos x	X position for all 12 trackers	Meters	**
Pos y	Y position for all 12 trackers	Meters	**
Pos z	Z position for all 12 trackers	Meters	**
Rot x	X rotation for all 12 trackers	Meters	**
Rot y	Y rotation for all 12 trackers	Meters	**
Rot z	Z rotation for all 12 trackers	Meters	**
Total 146 columns			

Figure 3.3: Detailed overview of logs produced by E(x|g)o per frame. L: learner, GV guidance visualistion, ED: euclidean distance. *head position and rotation is biased in exo-centric conditions because of multiple GV the L can focus on. **All trackers are logged for backup reasons: after the study is conducted a measurement can become interesting that was not of imporance before. With these values any measurement can be calculated post-study.

Task 1			Task 2			Task 3		
Sub-task#	Description	ST ID	Sub-task#	Description	ST ID	Sub-task#	Description	ST ID
	start in front of mirror, box on floor			start in front of mirror, box on floor			start in front of mirror, box on floor	
ST1	lift up box	lift	ST1	lift up box	lift	ST1	lift up box	lift
ST2	carry box to table	carry	ST2	carry box to scale	carry	ST2	carry box to table	carry
ST3	place box on table	place	ST3	lower box to scale	lower	ST3	place box on table	place
ST4	push box away	push	ST4	lift up box	lift	ST4	fold box away	fold
ST5	fold box away	fold	ST5	carry box to table	carry	ST5	walk to table center	walk
ST6	walk to left side of the table	walk	ST6	place box on table	place	ST6	turn box left	turn
ST7	fold box to bottom	fold	ST7	push box away	push	ST7	fold box to bottom	fold
ST8	pull box	pull	ST8	walk to right side of table	walk	ST8	push box away	push
ST9	pick up box	pick	ST9	pull box	pull	ST9	walk to right side of table	walk
ST10	carry box to scale	carry	ST10	push box away	push	ST10	pull box	pull
ST11	lower box to scale	lower	ST11	walk to table center	walk	ST11	fold box away	fold
ST12	lift up box from scale	lift	ST12	fold box left	fold	ST12	turn box right	turn
ST13	carry box to table	carry	ST13	turn box right	turn	ST13	push box away	push
ST14	place box on table	place	ST14	fold box to bottom	fold	ST14	walk to table center	walk
ST15	turn box left	turn	ST15	turn box left	turn	ST15	fold box to bottom	fold
ST16	push box away	push	ST16	push box away	push	ST16	turn box left	turn
ST17	pull box	pull	ST17	turn box left	turn	ST17	pick up box	pick
ST18	turn box right	turn	ST18	pull box	pull	ST18	carry box to scale	carry
ST19	fold box away	fold	ST19	fold box away	fold	ST19	lower box to scale	lower
ST20	pull box	pull	ST20	turn box right	turn	ST20	lift up box from scale	lift
ST21	walk to left side of table	walk	ST21	walk left side	walk	ST21	lower box to scale	lower
ST22	pull box	pull	ST22	pull box	pull	ST22	lift up box from scale	lift
ST23	turn box right	turn	ST23	fold box to bottom	fold	ST23	carry box to table	carry
ST24	push box away	push	ST24	push box away	push	ST24	place box on table	place
ST25	fold box to buttom	fold	ST25	walk to table center	walk	ST25	push box away	push
ST26	push box away	push	ST26	pull box	pull	ST26	pull box	pull
ST27	walk to scale	walk	ST27	pick up box	pick	ST27	turn box right	turn
ST28	walk to box on table	walk	ST28	place box on table	place	ST28	walk to right side of table	walk
ST29	turn box left	turn	ST29	pick up box	pick	ST29	pull box	pull
ST30	pick up box	pick	ST30	carry box to scale	carry	ST30	push box away	push
ST31	carry box to (invisible) mirror	carry	ST31	lower box to scale	lower	ST31	pull box	pull
ST32	put box on floor	lower	ST32	lift up box	lift	ST32	pick up box	pick
ST33	lift box up	lift	ST33	carry box to (invisible) mirror	carry	ST33	carry box to (invisible) mirror	carry
ST34	put box to ground	lower	ST34	lower box to ground	lower	ST34	lower box to ground	lower

Table 3.1: tasks

Sub-task ID	Sub-task description	Professional‘s description	#of sub-tasks/Task
push	Push box on table	Lunge, feet hip wide, chest out, shoulders back, straight back, lean forward, bend front knee, extend your arms, pressure on front leg, push box by activating back muscles	4
pull	Pull box on table	Lunge, feet hip wide, chest out, shoulders back, straight back, lean forward, bend front knee, extend your arms, pressure on front leg, pull box by activating back muscles	4
turn	Turn box by 90° on table	Feet hip wide, lean slightly forward with straight back, turn box with arm muscles, weight of the box remains on the table	4
fold	Put the box from one side to another on the table	Feet hip wide, straight back, slightly bended arms, depending on the distance to the box: lean over table, no bent knees, weight of the box remains on the table	4
carry	Translation in space with the box in hand	Chest out, straight back, bend elbows to 90°, box near to body, shoulder in neural-zero	4
walk	Translation in space without the box	“normal walking on their own judgment“, straight back	4
lift	Lift up the box from the floor	Approach box as near as possible, weight shifted slightly to the front, bend knees, open legs while going down, stop at the raised heels, lean forward with straight back, lift box with quadtriceps (tights), chest out, ellbows aim at ca. 90°	3
lower	Lower box to floor	Head above pelvis, bend knees and open legs, chest out, straight back and head, extend arms	3
place	Put box on table	Paralell hip wide feet, bend knees slightly, lean forward with straight back, lower arms	2
pick	Pick up box from table	Paralell hip wide feet, bend knees slightly, lean forward with straight back, lift with arms, abdominal and back muscles	2
			Total: 34 sub-tasks per task

Table 3.2: subtasks

Perspective	Speed Mechanic	Multiple Representations
Ego-centric	Yes	No
Exo-centric	No	Yes
Ego & Exo-centric	Yes	Yes
Augmented Exo-centric	Yes	Yes
Ego & Augmented Exo-centric	Yes	Yes

Figure 3.4: mechanics comparison

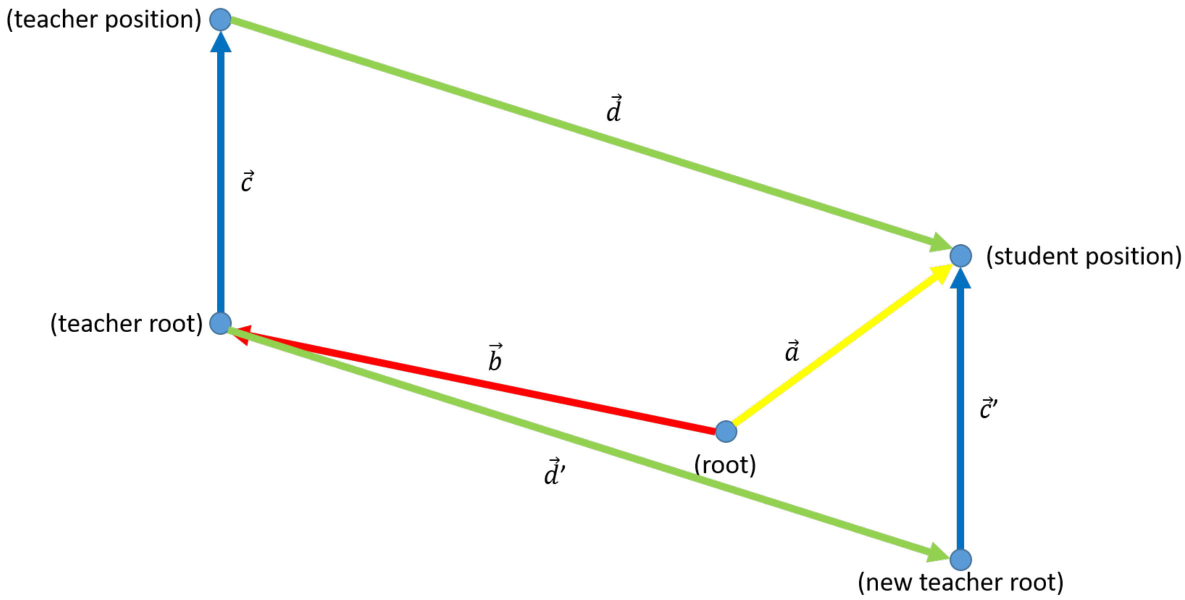

Figure 3.5: shift calc

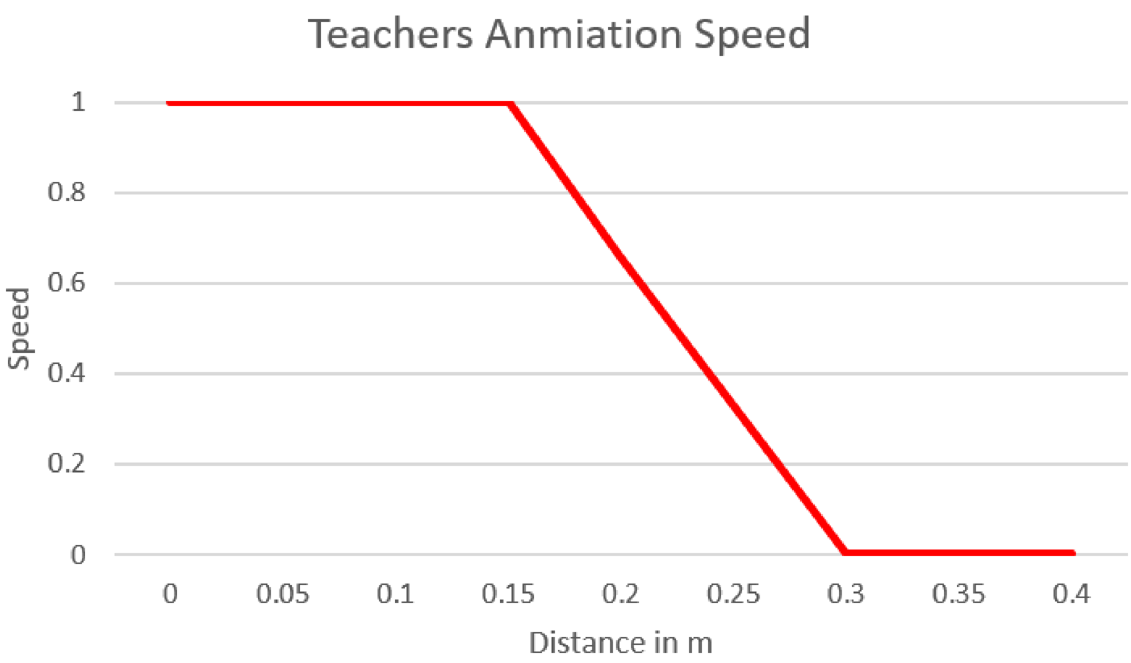

Figure 3.6: speed mechanic chart

	Session 1		Session 2		Session 3	
PT	Perspective	Task	Perspective	Task	Perspective	Task
PT1	Ego	T1	Exo	T2	Ego-Exo	T3
PT2	Ego	T3	Exo	T1	Ego-Exo	T2
PT3	Ego	T2	Exo	T3	Ego-Exo	T1
PT4	Ego & Exo	T3	Ego	T1	Exo	T2
PT5	Ego & Exo	T2	Ego	T3	Exo	T1
PT6	Ego & Exo	T1	Ego	T2	Exo	T3
PT7	Exo	T2	Ego-Exo	T3	Ego	T1
PT8	Exo	T1	Ego-Exo	T2	Ego	T3
PT9	Exo	T3	Ego-Exo	T1	Ego	T2

Figure 3.7: session plan

4 Study Evaluation

(5 pages)

4.1 Study Evaluation

aufgrund der Pilotstudie beschreiben, welche elemente gut bzw schlecht sind.
Wird gemessen was gemessen werden soll
sind die positionen der lehrer ok
sind tisch und box geeignet
gibt es schwierigkeiten etwas zu verstehen
ist die aklimatisierungsmethode angebracht
wie ist die dauer der durchführung einer session
sind die gestellten fragen am ende zielführend
pausen zwischen den sessions
sind die anweisungen die gegeben wurden zu viel/zu wenig
...
refinements

5 Conclusion

(3 pages)

5.1 System and Study

Zusammenfassung der Evaluation des Systems über die eignung zur durchführung einer Studie die daten generiert um die Forschungsfrage zu beantworten.
Zusammenfassung was gut und schlecht ist bei der Studienausführung.
reflexion und contribution, inkl. zu erwartende empirische contribution

5.2 Outlook

Was kann noch evaluiert werden mit diesem system?
anderer task ohne physical load, sitzend zur bedienung von maschinen ,realismusgrad der avatare, anzahl avatare, position von avataren, geschwindigkeit der anleitungsanimation...
wer hat welchen nutzen von der beantwortung der forschungsfrage: designer von motorlearning vr systemen.
bezug zu erweiterungen der implementierung
possible improvement: DTW https://towardsdatascience.com/dynamic-time-warping-3933f25fcdd

6 Attachments

6.1 Task description

6.2 Study Documents

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