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

Masterarbeit

vorgelegt von

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Universität Konstanz

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Konstanz, 2021

Abstract

Beautiful Study Design that works perfectly. No Doubt.

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1 Introduction

(3 pages)
The aquisition of movements is a crucial part in human development. Learning movements empowers to be more efficient, faster and more exact. This 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.
A lot of movements we learn by mimicing: watching and trying it out by yourself. But mastering a movement is performed best with a experienced teacher. A teacher is hardly replaceable because of imediate visual hand haptical feedback on a performed movement. But if a teacher is not available, for example based on the location or economic reasons, other sources to learn movements can be used to learn movements. For example, YouTube[1], TikTok[2] and other video plattorms have become a great source for learning videos for a wide rage of purposes. The downside of videos is 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 motorlearning for tasks like dancing todo: YouMove, VR Dance Trainer, OutSide Me, Performance Training, MR Dance Trainer, sports todo: Free Throw Simulator, Training Physical Skill, Rehabilitation todo: MotionMA, Physio @Home, KinoHaptics, SleeveAR, arts todo: AR-arm, just follow me, stylo and handifact, e-learning martial arts, my thai chi coaches, RT gestrue Recognition, onebody, thai chi trainer chua and others todo: TIKL, LightGuide.
In the real world, where student and teacher are real persons, the student sees the teacher for example in front of himself/herself. This is called the exo-centric visual perspective. But 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 of the students 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 potentionally influences Motor Learning todo: sources.
AR-Arm todo: source lets the learner experience the ... from an ego-centric perspective. YouMove teaches dance from an exo-centric perspective. OneBody, Light Guide, MR Dance Trainer, Free Throw Simulator, Training Physical skills, Sleeve AR and Thai Chi Trainer use both visual perspectives. But only OneBody, LightGuide and TaiChi Trainer found a difference in the perspectives, and, furthermore did no investigation on how the visual perspective influenced the performance of the learner. This shows the necessity of investigations on the influence of the visual perspectives on virtual guidance visualisations for motor learning.
Another topic, where Motor Learning is a valuable helper are ergonomic condiction of movements todo: physio at home, max papers?. The correct handling of physical load in the correct ergonomic conduct in working routines can prevent injuries in everyday life. But teaching kinaestetics is not always accessible for example economic reasons. this field is also very low investigated. In addition, the translation through space in ego centric perspective is not existing.
This work adresses the lack of knowledge about the influence of visual perspectives on, virtual guidance visualisaiton for motor learnign. thats why these research questions:

RQ1: Does the visual perspective on a virtual guidance visualisation influence motor learning in VR environments?
subs:

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

RQ1.1 Does the visual perspective on a virtual guidance visualisation influence the accuracy of movements?

RQ1.1.1 Does the visual perspective on a virtual guidance visualisation influence the accuracy of movements of the own Body?

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

RQ1.1.3 Are there sub-tasks that are influenced by the visual perspective on a virtual guidance visualisation?

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

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

[1]

1.1 Outline

übersicht über dieses dokument E(x|g)o

Motivation: Motorlearning wichtig zur aneignung von bewegungen. am besten mit echtem lehrer. wenn dieser nicht verfügbar, motor learning in VR möglich und sinnvoll, siehe xyz. allerdings ist der einfluss der perspektive auf die virtuelle guidance vis. noch wenig untersucht. deswegen diese arbeit hier.
ferner, wenig motorlearning in zusammenhang mit physical load und wenig "laufen mit egozentrischer anleitung".
Daraus folgt die forschungsfrage ... und ihre sub forschungsfragen ...
Um daten zu generieren um diese forschungsfragen zu beantworten wurde Exgo entwickelt. Eine studie wurde designed um mit diesem system die notwendigen daten zu generieren.
Diese arbeit beschreibt design und entwicklung von exgo, sowohl als auch die entwicklung dieser studie. EIn pilottest und dessen überarbeitung ist angeschlossen. auch weiter forschungsmöglichkeiten mit dem system sollen aufgezeigt werden.
Forschungsfragen:

2 Motor Learning in Virtual Reality

(5 pages)

2.1 Motor Learning

grundlagen des motor learning

2.2 Visual Perspectives

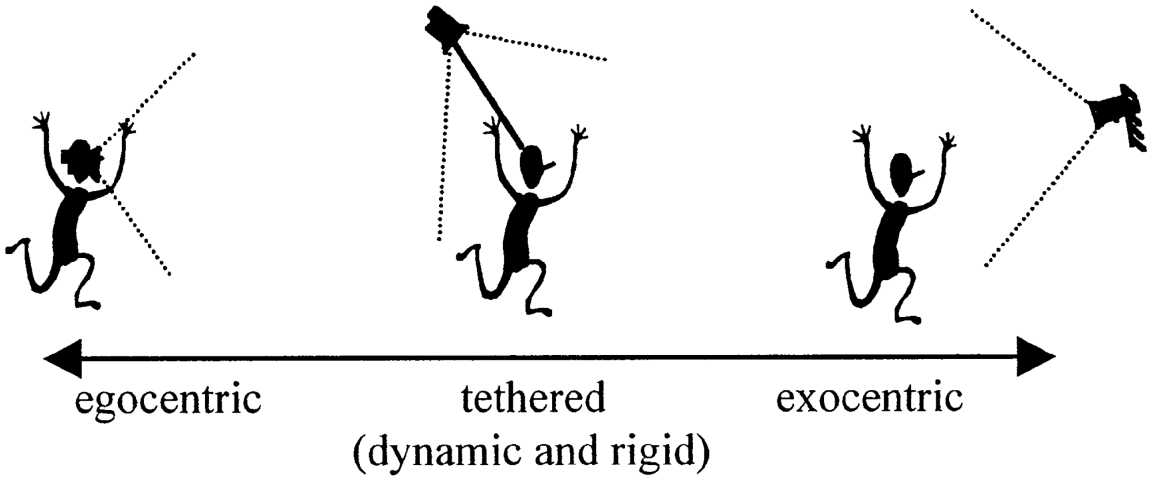

Figure 2.1: Ego-centric / exo-centric continuum by Milgram todo: source

ego-exo continuum,

2.3 measurements for motorlearning?

2.4 Mixed Reality

argumentation warum VR und nicht AR?

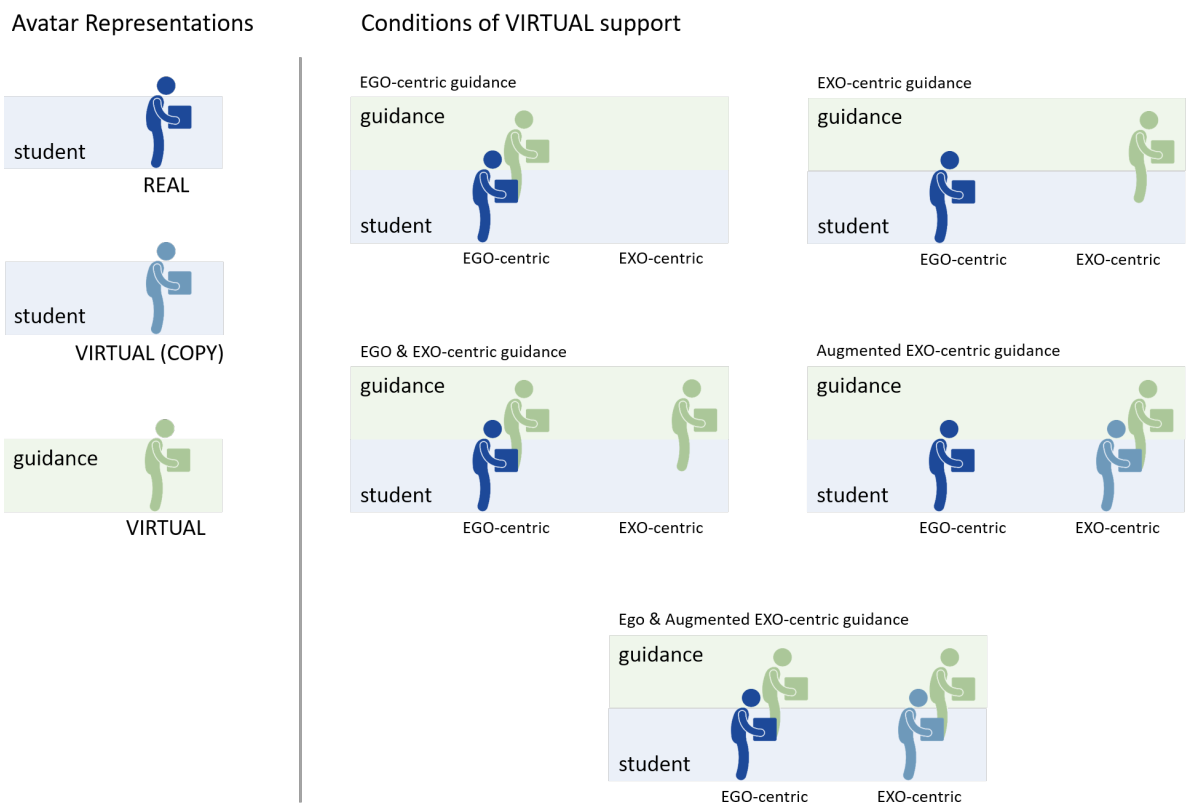

Figure 2.2: Possible perspectives with one real world student and one real world teacher.

2.5 Motorlearing in Virtual Reality

bekannte arbeiten und deren ergebnisse über motor learning in VR

auf basis dieses kapitels wird die studie geformt

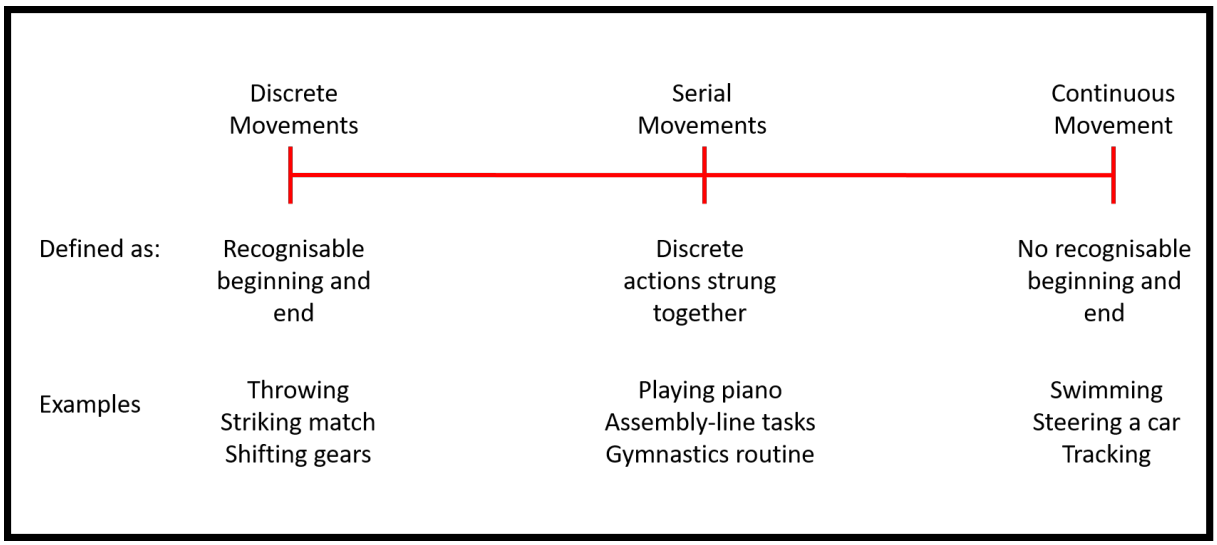

Figure 2.3: Movement classification 1

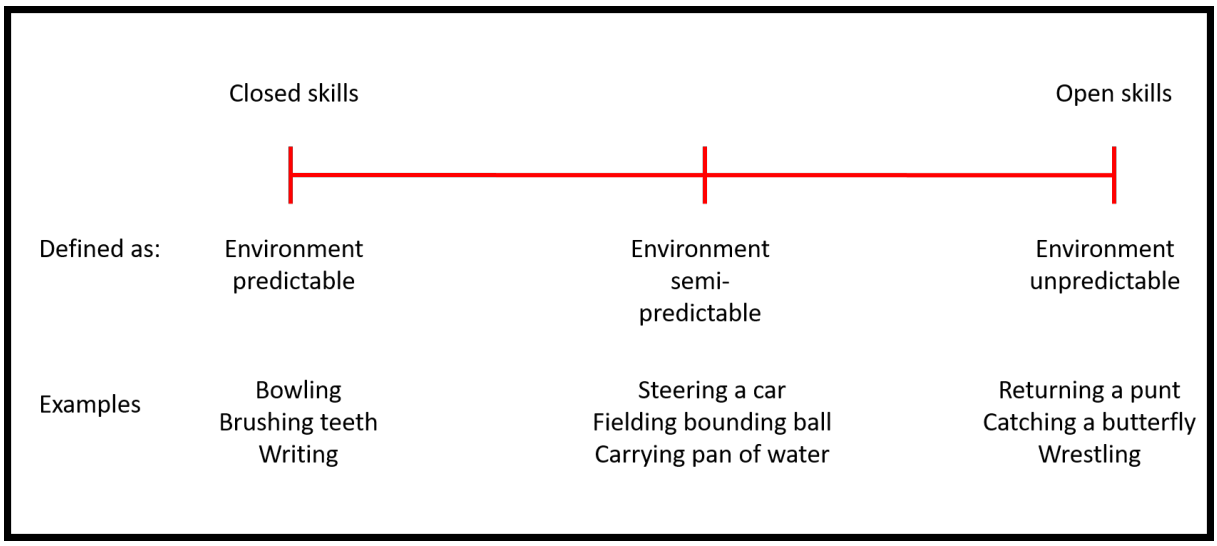

Figure 2.4: Movement classification 2

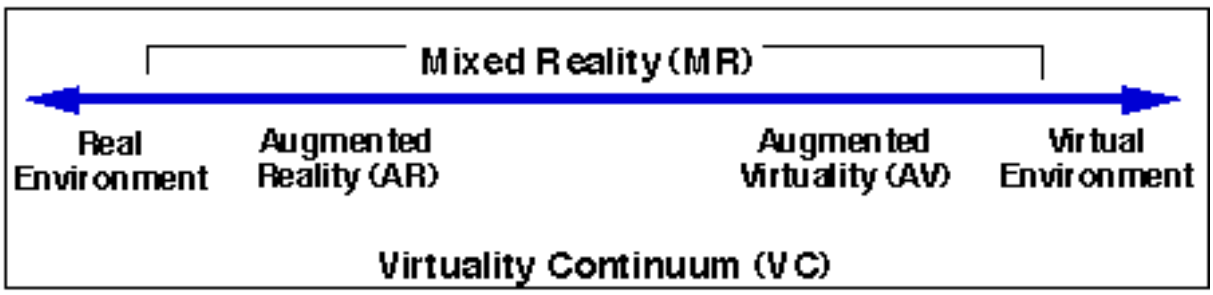

Figure 2.5: Ego-centric / exo-centric continuum by Milgram todo: source

	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 Conceptual Delimitation and Contribution Statement

abgrenzung zu related work und klares contribution statement
contribution type

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

(15 pages)

4.1 System

Studysetup
frameworks
implementation
perspectives
mechanics
logging
limitations
iterative implementation
formative tests

4.2 Study

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

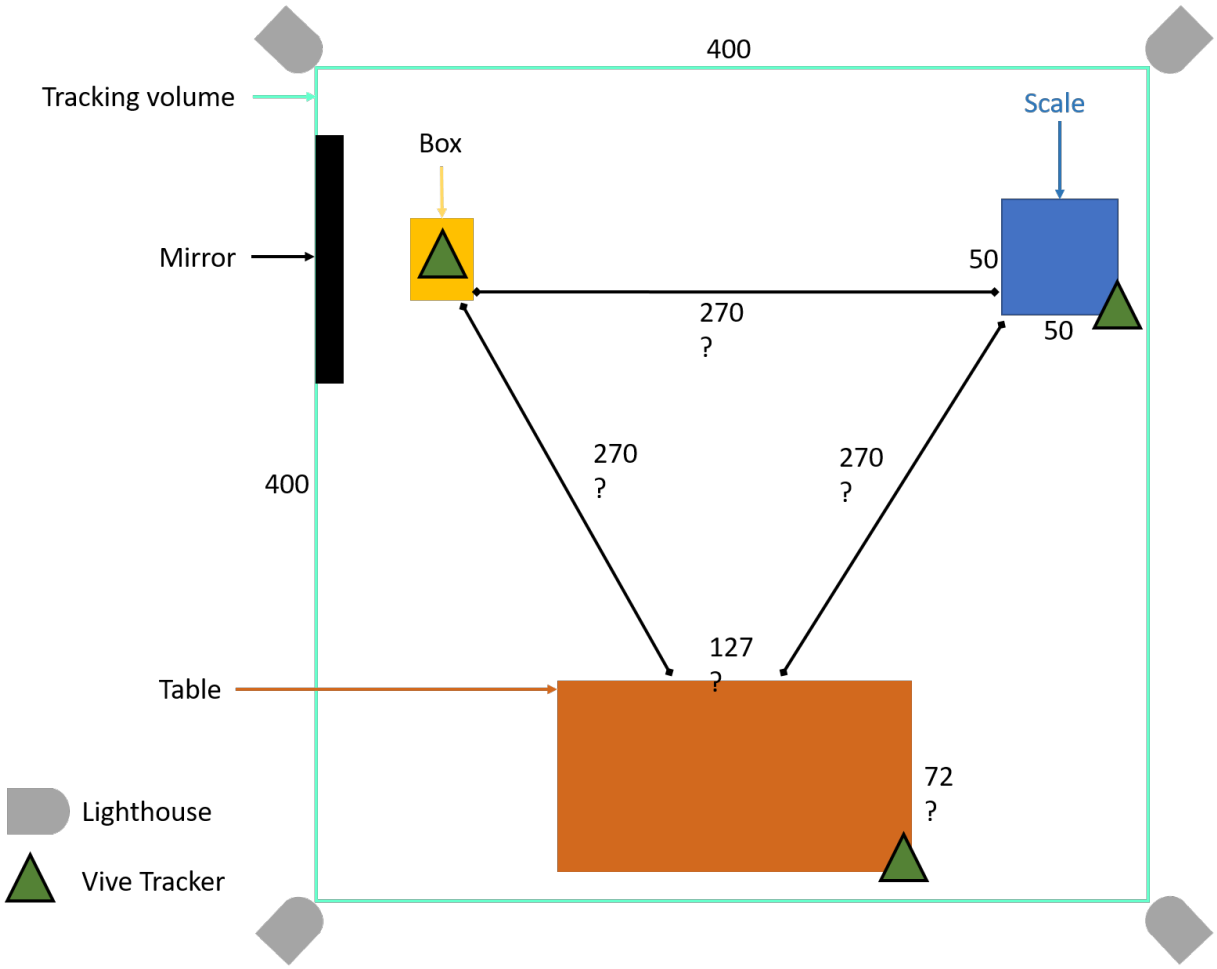

Figure 4.1: study setting

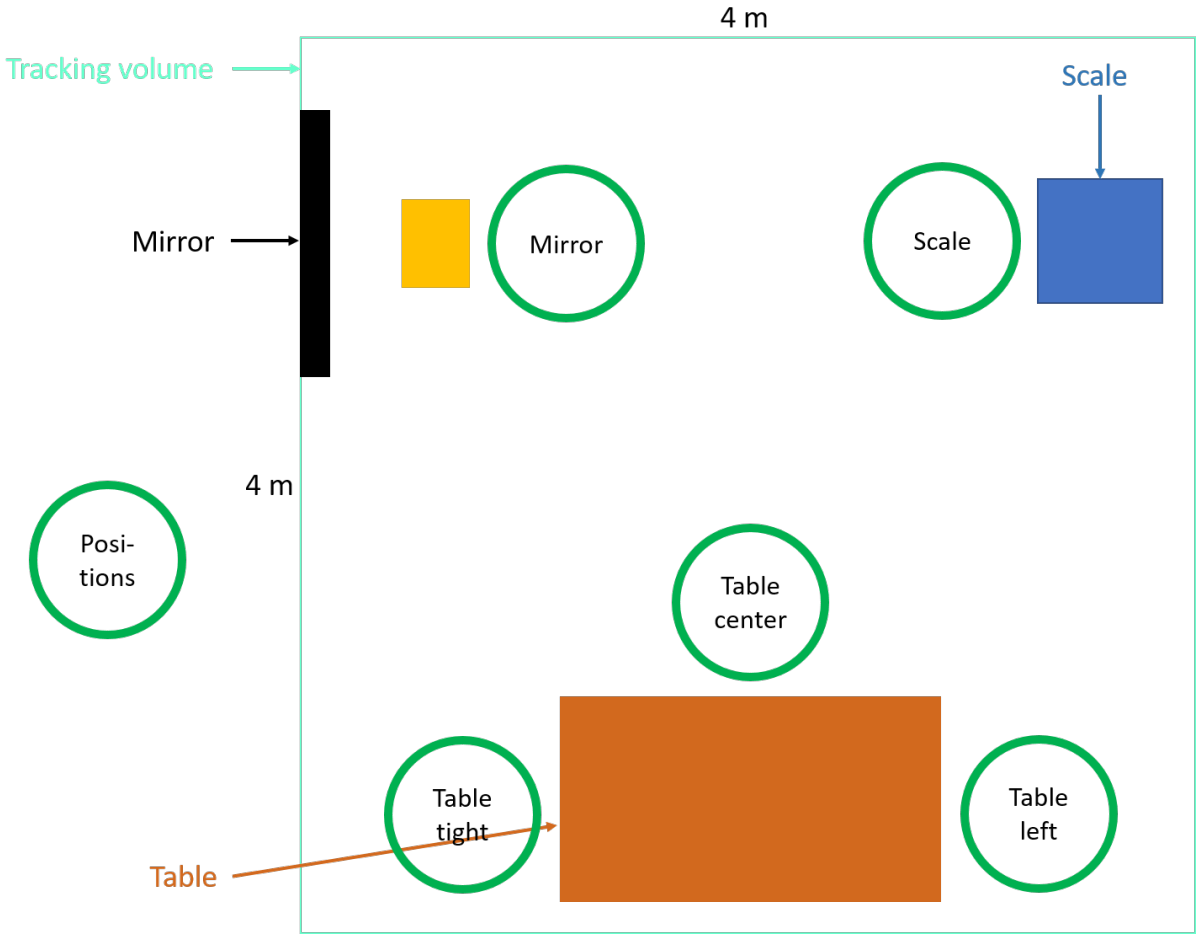

Figure 4.2: tasks

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 4.3: 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 4.1: tasks

Sub-task ID	Sub-task description	Professional's comment	Amount of sub-tasks per Task
pull	pull box on table	Lunge, feet hip wide, chest out, straight back, lean forward, bend front knee, extend your arms, pressure on front leg, pull box by activating back muscles	4
push	push box on table	Lunge, feet hip wide, chest out, straight back, lean forward, bend front knee, extend your arms, pressure on front leg, push 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	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 bended knees, weight of the box remains on the table	4
carry	translation in space with the box in hand	Chest out, straight back, elbows bended on nearly 90°, box near to body	4
walk	translation in space without the box	"normal walking on their own judgment"	4
lift	lift up the box from the flor	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 in tights, chest out, ellbows aim at ca. 90°	3
lower	Lower box to flor	Head above pelvis, bend knees and open legs kopf über becken beim aufstehen, kknie beugen und öfnen, brust raus, kopf gerade, gerader rücken	3
place	put box on table	knie beugen, leicht nach vorne beugen, ame setzen box ab	2
pick	pick up bock from table	box weit weg dann ausfallschritt, box nah, dann in die knie und paralele füße	2
			Total: 34

Table 4.2: subtasks, needs adjustments by selma

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 4.4: mechanics comparison

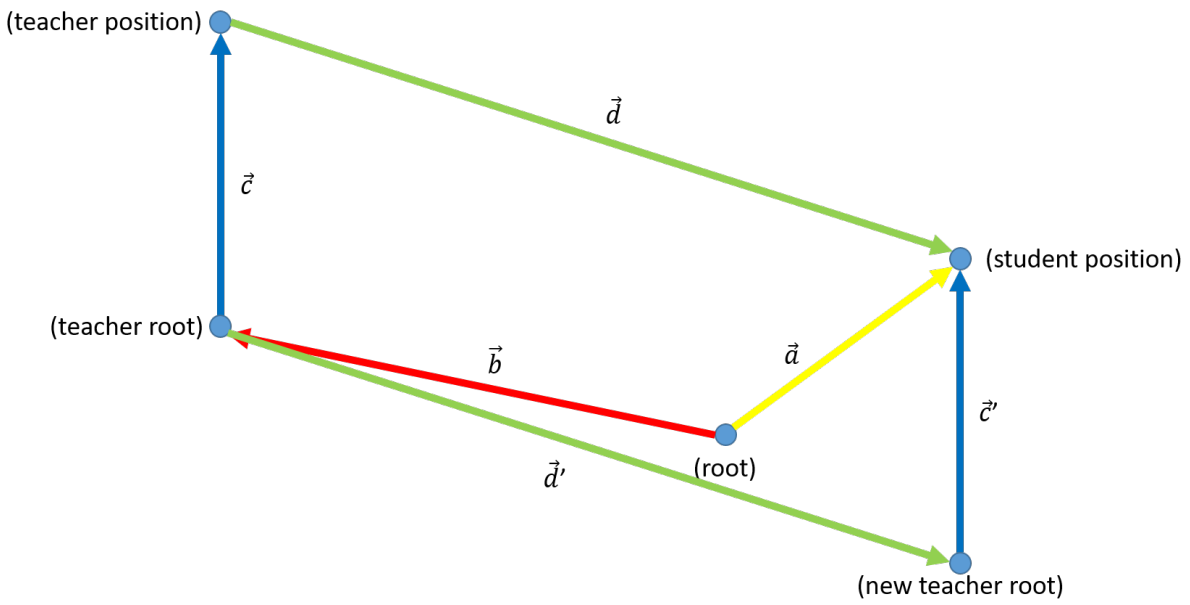

Figure 4.5: shift calc

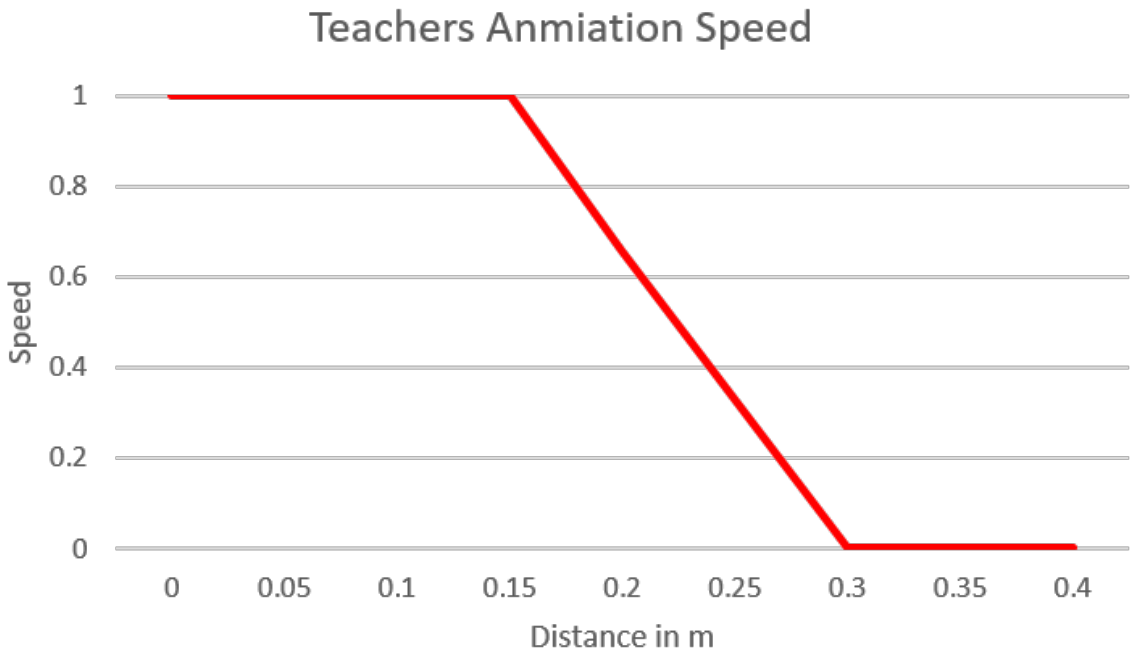

Figure 4.6: speed mechanic chart

	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 4.7: session plan

5 Study Evaluation

(5 pages)

5.1 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

6 Conclusion

(3 pages)

6.1 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

6.2 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

7 Attachments

7.1 Task description

7.2 Study Documents

References

[1] Jonathan Muckell, Yuchi Young, and Mitch Leventhal. "A Wearable Motion Tracking System to Reduce Direct Care Worker Injuries: An Exploratory Study". In: *Proceedings of the 2017 International Conference on Digital Health*. DH '17. London, United Kingdom: Association for Computing Machinery, 2017, 202–206. ISBN: 9781450352499. DOI: 10.1145/3079452.3079493. URL: https://doi.org/10.1145/3079452.3079493.