Investigating the influence of perspectives on a virtual avatar for motor learning

Stefan Paul Feyer
HCI Group, University of Konstanz

February 7, 2019

Contents

0.1 Abstract

- Overall aim of the Seminar thesis: how to investigate the influence of perspectives on virtual avatars in MR for motor learning
- therefore analysis of motor learning, related work, research questions
- propose study setting

Chapter 1

Introduction

1.1 Motivation

In recent years, MR devices became more affordable [1], portable [2] and usable in many conditions. Not only academic researchers are interested in this technology, commercial companies also found this technology helpful to explore new possibilities to use it profitable. EON [3] for example calls themself "the world leader in Virtual Reality based knowledge transfer for industry, education, and edutainment". They develop MR programs for several platforms, eg. with the aim to guide workers, reducing mistakes and thus reducing costs.
Since MR learning or guiding programs reached the commercial market, many applications will be created. It is important to build these applications on well founded research.
Developing a system for MR learning can be complex and mistakes can be made. Providing a developer with guidelines to design such a program could help decreasing design faults. But before guidelines can be created, groundwork has to be done and be investigated with sophisticated research methods. This seminar thesis will take a look in the background of motor learning and perspectives to conduct groundwork that later can be used for guidelines for designing a MR motor learning system.

1.2 Problem definition and RQ

- Motor learning tasks can be learn in MR (quellen)

---

[1] **TODO**
[2] **TODO**
[3] **TODO**

- investigations in xyz but not in terms of perspective
- influence of perspective could lead to insights/ recommendations for learning in MR

Overall rq

- How does perspectives on virtual avatars influence motor learning?

1.3 Approach

- Design a Study, participants to perform movements
- two groups, ego/exo perspective, 2 movement types
- investigate the performace of the groups

1.4 outline

After this introduction, the scope of this thesis is given, where it is explained to what extend motor learning, MR, perspectives and other factors are considered. The following related work part will give an overview about other MR learning systems and also work about perspectives on avatars. From this work the measures, dependent and independent variables and tasks are derived. Taking the related work into consideration a study design is proposed in outlook section.

Chapter 2

Theoretical Background

2.1 Movements

How do we learn movements

Movement classification

For a simplified discussion a classification of movements is provided in the following. There are two important classification schemes. The first one is based on the particular movements performed and are divided into *discrete*, *continuous* and *serial movements*. The second one is based on perceptual attributes of the task and are divided into *open* and *closed skills*. Both classification representing a continuum.

Discrete, Continuous and Serial Movements

Discrete movements are located on the one end of the continuum. These are movements with a recognisable beginning and end. The end of a discrete movement is defined by the task itself and can be very rapid like blinking or longer like making the signing. Examples are kicking a ball, shifting gears in a car or striking a match
Continuous movements are located on the other end of the continuum. These movements don't have a recognisable start and end, with behaviour continuing till the movement arbitrarily stopped. Continuous tasks tend to be longer than discrete tasks. Examples are swimming, running or steering a car.
Serial movements are located in the middle part of the continuum. Following the nature of a continuum these movements are neither discrete nor continuous. They can consist of smaller movements tied together. Further-

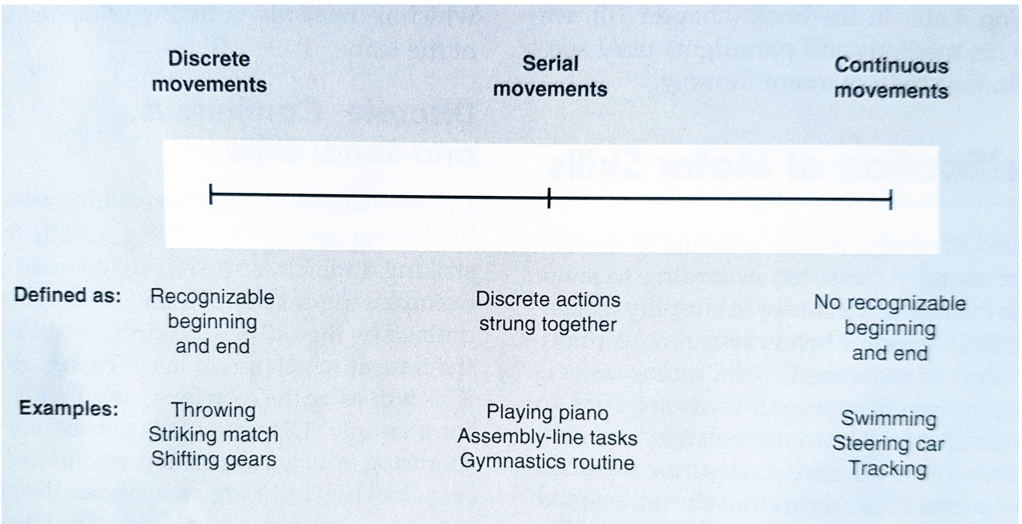

Figure 2.1: Continuum of movements buch **TODO**

more, discrete movements can be rather long but are not stopped arbitrarily. Serial tasks can be seen as many discrete tasks strung together and the order (and sometimes timing) is important. Examples are starting a car or preparing and lighting a wood fireplace.

Open and Closed Skills

Open skills: The environment is constantly, unpredictably changing, so the performer cannot plan his activity effectively in advance. Own movements depend on the environment. For example, if a ice hockey player shoots a shot in ice hockey, his own movement is dependent on the movement of the keeper. Another example is driving on a free way. The driver needs to adjust his own driving dependent on the behaviour of the other cars. Success in open skills is largely determined by the extend to which a individual can adapt the planned motor behaviour to the changing environment.
Closed skills: The environment is predictable, mainly because it is stable. This means that the performer can plan his activity in advance. Examples are bowling, archery or singing. **TODO**+ citations

How to quantify movements

Judging motions and matching them to a given motion is not a trivial task. One approach follows Rudolph von Laban - a professional dancer. Von La-

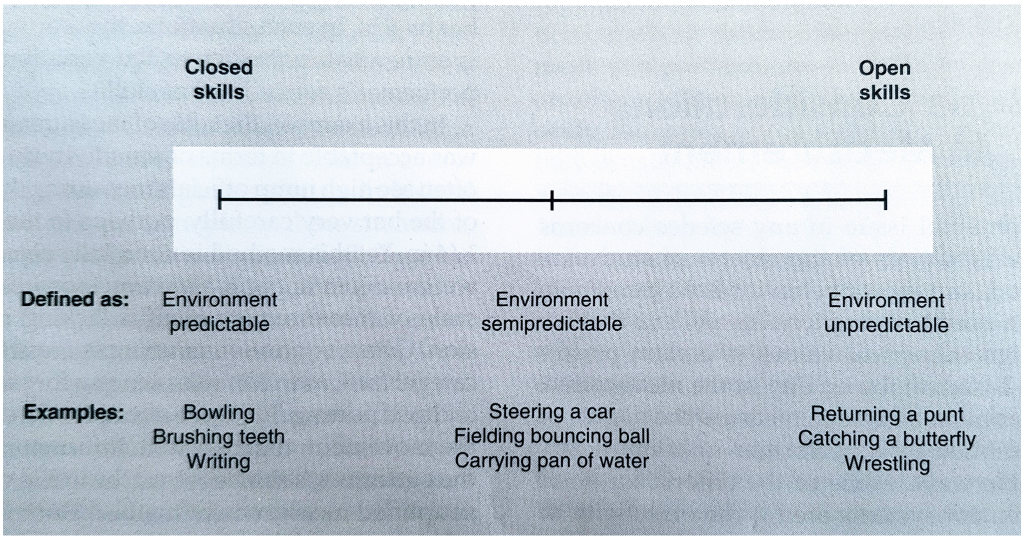

Figure 2.2: Continuum of skills buch **TODO**

ban developed a broadly used dance notation. His work lead to the *Laban Movement Analysis* with which human movements could be quantized.[1] There are four main components to systematically describe movements in the *Laban Movement Analysis*: body, effort, shape and space. Each component can describe movements independently or combined. Hachimura et al. **TODO**used the methodology of *Laban Movement Analysis* and adopted it to for digital movements.
Yoshimura et al. **TODO**followed a similar approach from another dance movement description theory called *furi*. *Furi* is also described by four so called *indices*: *kamae*, *jyu-shin*, *koshi*, *uchiwa*. Yoshimura at all could map these indices to concrete markers on the body of a performer. Qian et al. **TODO**developed a gesture recognition system for performing arts. To match the motions ten body parts were defined: head, torso, upper arms, forearms, upper legs and lower legs. For each body part the Mahalanobis distance is calculated to an ideal point. The Mahalonobis distance describes the distance between point p and distribution D. Kwon et al. **TODO**

- K. Hachimura, K. Takashina, and M. Yoshimura, "Analysis and Evaluation of Dancing Movement Based on LMA," Proc. IEEE Int'l Workshop Robots and Human Interactive Comm., pp. 294-299, 2005.

- M. Yoshimura, N. Mine, T. Kai, and L. Yoshimura, "Quantification

[1] Brockhaus, Rudolf Laban. http://www.brockhaus.de/ecs/enzy/article/laban-rudolf (accessed 2018-10-25)

of Characteristic Features of Japanese Dance for Individuality Recognition," Proc. IEEE Int'l Workshop Robot and Human Interactive Comm., pp. 193-199, Sept. 2001.

- G. Qian, F. Guo, T. Ingalls, L. Olson, J. James, and T. Rikakis, "A Gesture-Driven Multimodal Interactive Dance System," Proc. IEEE Int'l Conf. Multimedia and Expo (ICME '04), pp. 1579-1582, June 2004.

- D.Y. Kwon and M. Cross, "Combining Body Sensors and Visual Sensors for Motion Training," Proc. ACM SIGCHI, pp. 94-101, 2005.

- vr dance trainer

How to measure movements

In order to judge if a movement is performed correctly methods need to be applied to measure the error of a performed action. In literature, three main categories are listed: error of a single subject, measures of time and speed and measures of movement magnitude.

Measures of Error for a Single Subject

Measures of error for a single subject represent the degree to which the target was not achieved. A target can be to perform an act at a particular time (time stamp), move with a certain force (amount of force) or hit a spatial target (a point in spatial volume). The attribute of the target serves as the variable in question, see braces behind the examples. The error itself describes the distance - in regard to the dimension - from the target. The following list gives an insight to the most important error measures.

- ***Constant Error*** describes the average error between the actual accuracy and the target. Means, in average the performer missed the target by CE.
$$CE = \frac{\sum_i (x_i - T)}{n} \tag{2.1}$$
with x_i: score, n: number of values, T: target value.

- ***Variable Error*** measures the inconsistency in movements. The more consistent the movements, the smaller VE. VE does not depend on whether or not the subject was close to the target.
$$VE = \sqrt{\frac{\sum (x_i - M)^2}{n}} \tag{2.2}$$

- ***Total Variability*** describes the total variability around a target. The combination of VE and CE represents the total amount of spread about the target. It is an overall measure how successful was the subject in achieving the target.

$$E = VE^2 + CE^2 = \sqrt{\frac{\sum (x_i - T)^2}{n}} \tag{2.3}$$

  with x_i: score, n: number of values, T: target value.

- ***absolute error*** is a measure of the overall accuracy in performance.

$$AE = \frac{\sum |x_i - T|}{n} \tag{2.4}$$

  with x_i: score, n: number of values, T: target value.

- ***Absolute Constant Error*** is the absolute value of CE. Because of negative and positive values can cancel each other out

$$ACE = |CE| \tag{2.5}$$

these measures can be applied to other movements. like pursuit motor: TOT, Mashburn task, stabilometer, two hand coordination task.

Measures of Time and Speed

measures of time and speed: basic to this idea: performer who can accomplish more in a given amount of time or who can accomplish a given amount of behavior is more skillfull. time measure:c $\frac{time}{unit}$. speed: $\frac{units}{time}$.

reaction time (RT): can also be a performance measure. a measure of time from the arrival of a sudden and unanticipated signal to the beginning of the response.

Measures of Movement Magnitude

movement time (MT): how long does the movement last. somtimes commbined with RT: response time= $RT + MT$

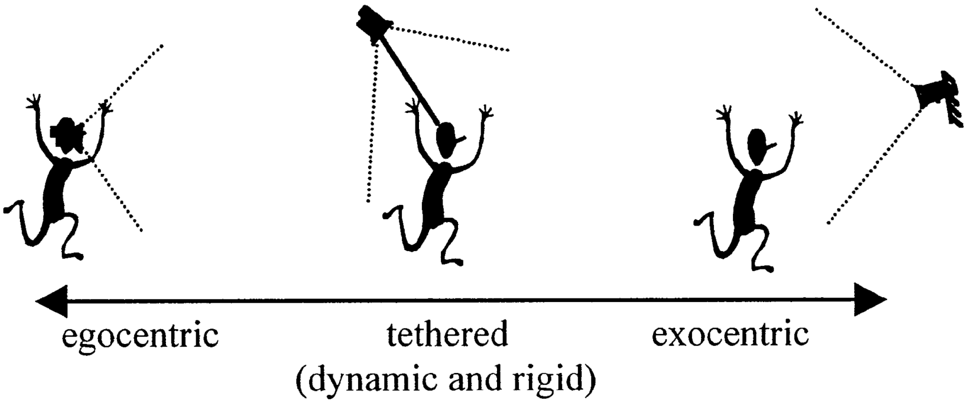

Figure 2.3: Centricity continuum by Wang and Milgram 2001 **TODO**

2.2 Perspectives

Wang and Milgram **TODO**describe the perspectives on the centricity continuum see 2.3. On the most left hand side of the continuum the egocentric perspective is located. Egocentric means that the anchor of the viewport camera is located inside the object to control - for simplicity, this object in question is referred as avatar. On the left hand side the exocentric perspective is located. This viewport camera is a fixed camera in the scene not to be controllable. The exocentric perspective gives the user the possibility to examine the scene from a bird's-eye view. The movement or angle of the avatar has no influence on the cameras position or angle. So the main difference is the so called tether distance and the degree of freedom of the camera. Milgarm and Wang investigated on tethered cameras and define it as the distance between the avatar and the camera which is following the avatar. This describes the middle part of the continuum. Zero-distance camera describes the egocentric perspective. The longer the tether distance the more the perspective is located on the right of the scale to the exocentric perspective. They also distinguish between dynamic and rigid tethering relation ships. A dynamic tethered camara is controlled by the user in all six dofs (**TODO**) while a rigid stands like a pole and can only be controlled in 3 dofs. Rigid tethered cameras are common in modern 3rd person computer games.

Chapter 3

Scope

3.1 Motor Learning

- discrete movements
- closed skills
- at least 2 different movement categories
- how to measure movements

3.2 Mixed Reality

- Milgram
- AR or VR

3.3 Perspective

3.4 Misc

- synchron asynchron
- colocated/remote
- perspective
- hardware?
- feedback!

- real world, not abstract avatars
- only visuals - no audio or textual explanation

Chapter 4

Related Work

4.1 Aggregated overview about paper describing MR learning systems

hier werden einige paper über MR lern systeme vorgestellt. gestaffelt nach:

Tasks

Measures

Method

Variables

4.2 Detailed description of 6-10 papers incl. Table

hier werden die paper detailiert vorgestellt von denen ich dann meine tasks, measures, methode und variablen ableite. am ende zusammenfassung in einer tabelle

4.3 Conclusion (and research questions/hypothesises?)

hier wird zusammengefasst was ich abgeleitet habe und direkt in das studien design einfließt. danach folgen die genauen RQ und hypothesen.

Chapter 5

Outlook

5.1 Preliminary Study design

Aim of the Study

The aim of the study is to investigate the influence of egocentric and exocentric perspectives on a virtual avatar during motor learning tasks.

process

There are two groups: one learn only with the egocentric perspective, the other one with the exocentric perspective on the virtual avatar.
To derive conclusions on body regions, every participant learns movements for three different body parts. The body parts are:

- *upper body*(UB)
- *lower body*(LB)
- *full body*(FB)

To derive conclusion on movement types, two different movements per body part is learned. The two movement types are:

- mirrored movements
- independent movements

	UB	LB	FB
Ego	1 mirrored and 1 asynchronous movement	1 mirrored and 1 independent movement	1 mirrored and 1 independent movement
Exo	1 mirrored and 1 independent movement	1 mirrored and 1 independent movement	1 mirrored and 1 independent movement
Ego/Exo	1 mirrored and 1 independent movement	1 mirrored and 1 independent movement	1 mirrored and 1 independent movement

Independent variables

- perspective on the avatar (Ego/Exo centric)
- body parts (*upper body*, *lower body*, *full body*)
- movement types (mirrored/independent movements)

measures

TBA

5.2 Timetable