Prehension in Virtual Environments:

General Aspects of Grasping without Haptic Feedback and the Effects of Perturbations

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Cooperation within the RWTH Aachen University

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Overview

- Virtual reality as research method and as research topic
- Virtual reality and psychology in Aachen
- Psychomotor performance in virtual environments
  - Experimental studies
    - Method
    - Results
    - Discussion
- Final Statement

Virtual Reality as research method

General psychology
cognition, perception, psychomotor activity und attention

Neuropsychology
neuropsychological assessment and neuropsychological rehabilitation

Clinical psychology
therapy of phobias, eating disorders, addictions, PTSD, autism, schizophrenia, etc.

Motor rehabilitation

Applied disciplines (z.B. traffic psychology, ergonomics, HCI, etc.)

Virtual reality as research topic

Basic research
e.g. influences of 3D-presentation, depth perception, visuomotor coordination, influence of visualization techniques on memorizing and encoding processes, etc.

Realization research
Development of VR-systems based on cognitive, emotional and communicational findings

Evaluation research
Research of acceptance, efficiency and effectiveness and the determination of the social, cognitive and emotional effectiveness of VR-systems as well as the comparison of established media and VR-technologies

Virtual reality and psychology in Aachen

...research method

Psychomotor performance

How do object perturbations influence human grasping?

Attention

Orientation of attention in the three-dimensional space?

...research topic

Depth perception

How do we perceive spatial depth in virtual applications?

Psychomotor performance

How do we grasp virtual objects without haptic feedback?

Psychomotor performance in virtual environments

Which influence do object perturbations have on psychomotor control of prehension movements and can we replicate findings from reality in a virtual setting?

How do we grasp in virtual environment without haptic feedback?

Which differences exist between real and virtual grasping?

Is visual feedback sufficient to provide a grasp feeling?

Theoretical background

Human prehension is based on the processing of information from **two hypothetical visuo-motor channels** (Jeannerod, 1981): one for extrinsic object characteristics (e.g. spatial position) and one for intrinsic object characteristics (e.g. size).

The prehension movement itself can be divided in **two components**: the transport and the grasp component (MacKenzie & Iberall, 1994).

To study those channels and components perturbations experiments in real settings were used (e.g. Paulignan et al. 1991 a,b).

BUT

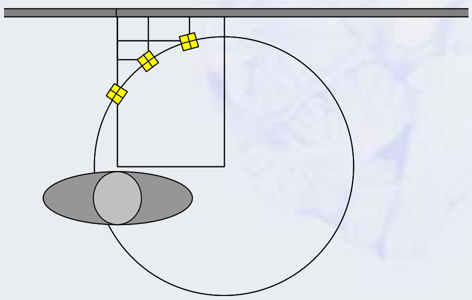
In reality those perturbation experiments have to face physical limitations.

➔ Virtual reality as the “perfect” research method without physical limitations.

Method – experimental setting and tasks

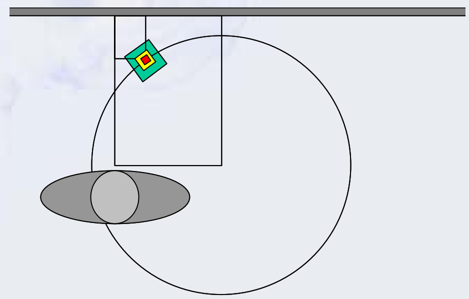
Experiment 1

perturbation of POSITION



Experiment 2

perturbation of SIZE



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Method – experimental design

Per experiment **60** calibration trials and **160** experimental trials were executed

➔ **220** grasp movements per participant were recorded

Exp.	Calibration trials	Experimental trials
1	**20** movements to the middle position **20** movements to the right position **20** movements to the left position	**80** movements without perturbation **40** movements with perturbation from the middle to the right **40** movements with perturbation from the middle to the left
2	**20** movements to the medium size **20** movements to the large size **20** movements to the small size	**80** movements without perturbation **40** movements with perturbation from medium to large **40** movements with perturbation from medium to small

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Method – VR implementation (Experiment 1)

3 object positions

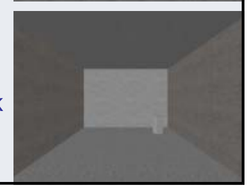
starting position

starting position

perturbation to the right

visual feedback

visual feedback



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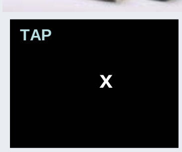
Method - sample

- Experiment 1 (perturbation of POSITION) :

  12 participants
- Experiment 2 (perturbation of SIZE):

  10 participants

- Age: 22 – 35 years
- Right handed (Oldfield Handedness Inventory, 1971)
- Normal or corrected to normal vision (Titmus Vision Tester)
- Normal performance in psychomotor (MLS) and atttention tests (TAP)



Method – recorded and analyzed parameters

- *Temporal parameters*

  reaction times, movements times, times to peak values

- *Spatial parameters*

  distances and ways, aperture

- *Peak values*

  velocity, acceleration, deceleration, aperture

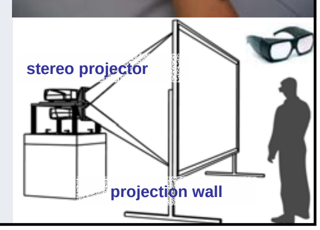
Method – technical data

Movement registration and head tracking

- Optical Tracking with the Qualisys Track Manager (QTM)
- 3 infrared cameras
- 2 single markers on thumb and index finger, 1 6DoF marker at the wrist
- 1 6DoF marker at the passive stereo glasses for head tracking

VR hardware and software

- stereo projection (resolution 1024x768) on projection wall (2.40 x 1.80 m), Infitec glasses
- ReactorMan software



Method – procedure

Pre-tests

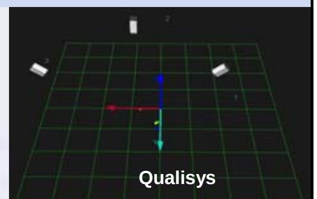
- MLS
- TAP
- interpupillary distance

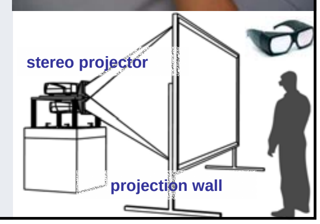
Experiment

- calibration and experimental trials

Post-Questionnaire

- virtual reality on 4 dimensions (presence, external awareness, quality, enjoyment), physical discomfort and experimental set-up





Results - calibration trials (eclectic)

experiment 1 POSITION	**left**	**middle**	**right**
*total movement time in ms**	1234,3 (291,8)	1348,9 (409,6)	1329,1 (334,0)
*grasp distance in cm***	38,0 (3,1)	43,7 (2,1)	45,7 (1,4)
experiment 2 SIZE	**small**	**medium**	**big**
*max. aperture in cm***	9,9 (3,9)	14,4 (5,0)	19,0 (5,7)
*endpoint aperture in cm***	5,3 (0,7)	7,6 (1,2)	11,8 (1,4)

➔ depth perception influences prehension movement (effect of distance)

➔ participants are able to grasp without haptic feedback (aperture values)

Results - experimental trials (eclectic)

experiment 1 POSITION	perturbation left	no perturbation	perturbation right
*total movement time in ms***	1363,8 (147,0)	1172,1 (224,4)	1495,5 (255,1)
*deceleration time in ms***	796,6 (124,9)	590,9 (198,8)	910,5 (227,5)
experiment 2 SIZE	**perturbation small**	**no perturbation**	**perturbation big**
*total movement time in ms***	1135,7 (150,9)	1102,3 (131,1)	1191,4 (107,0)
*deceleration time in ms***	615,4 (114,2)	578,1 (88,3)	663,3 (66,6)

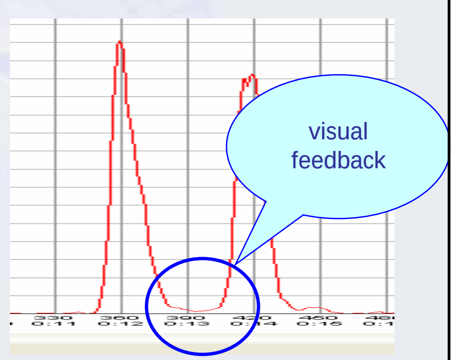
➔ perturbations influence the prehension movements (total movement times)

➔ prolonged movement times can be traced back on the prolonged deceleration time

Reality versus virtuality

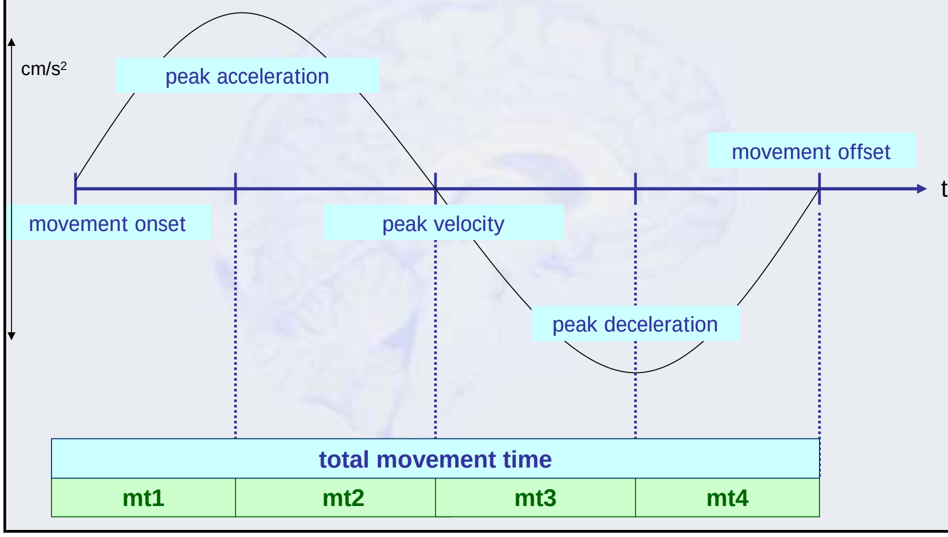
real grasping (240 Hz)

virtual grasping (30 Hz)



velocity profiles of the wrist

Reality versus virtuality



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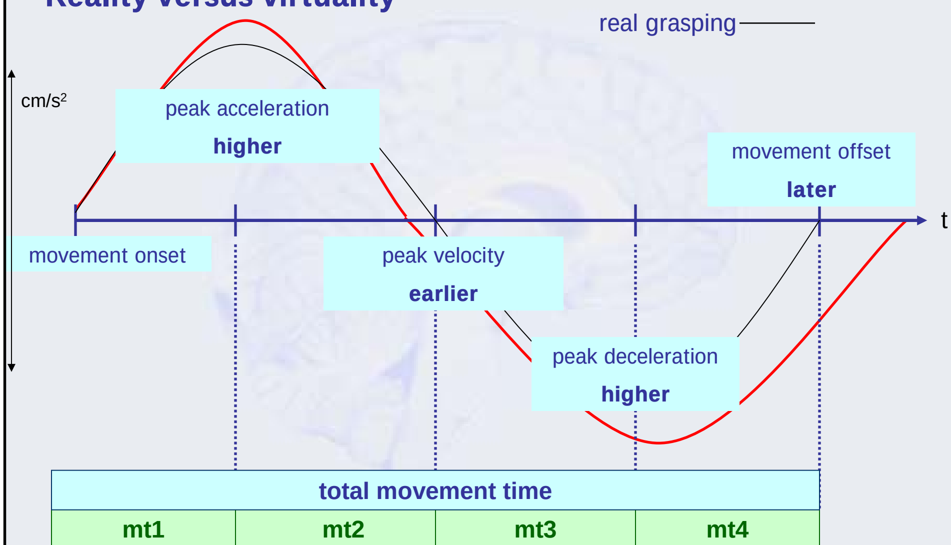
Reality versus virtuality

virtual grasping
real grasping

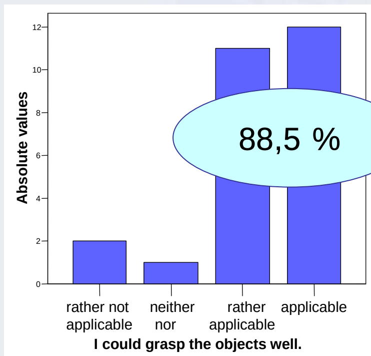


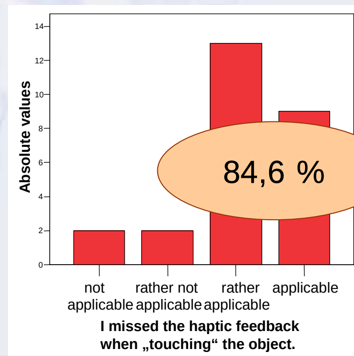
Results - post-questionnaire (eclectic)

Physical discomfort

- Experiment 1: 5 out of 12 (light headache, malaise and dizziness)
- Experiment 2: 2 out of 10 (light dizziness)

Experimental set-up: Haptic feedback





Psychomotor performance in VR

Which influence do object perturbations have on psychomotor control of prehension movements?

Mainly, prolonged deceleration phase

How do we grasp in virtual environment without haptic feedback?

Virtual grasping is very similar to real grasping

Which differences exist between real and virtual grasping?

Especially the last grasping phase is extended

Is visual feedback sufficient to provide a grasp feeling?

Yes

Virtual Reality in psychological research

Virtual reality is a promising **research method** in psychology,

but nevertheless it is necessary to examine virtual reality as **research topic** in the future,

because otherwise the interpretation and generalizability of the results from virtual applications are confounded by unknown factors.

Thank you for your attention