

The background image shows two individuals in a factory or industrial setting. In the foreground, a man is seen from the back, wearing a blue t-shirt and a grey and black exoskeleton. The exoskeleton has a large rectangular unit on his back with the brand name 'ottobock' visible. He is also wearing a grey and black arm brace on his right arm. In the background, a woman is smiling and looking towards him. She is also wearing a blue t-shirt and a similar exoskeleton. The setting appears to be a modern industrial facility with various equipment and structures visible in the background.

HUMAN-EXOSKELETON EXPERIENCE AND ITS CORPOREAL DIMENSIONS: Insights from a Qualitative Study

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01 EXOSKELETONS: BECAUSE HUMAN WORKFORCE IS ESSENTIAL

Automation has **economic** and **technological limits**

Musculoskeletal disorders (MSDs) are injuries or pain in the musculoskeletal system from sudden exertion, repetitive tasks or work in forced postures (DGUV 2022)

Exoskeletons (wearable assistive devices) can contribute to **decent working conditions** and the **individual well-being** (Maurice et al., 2020)

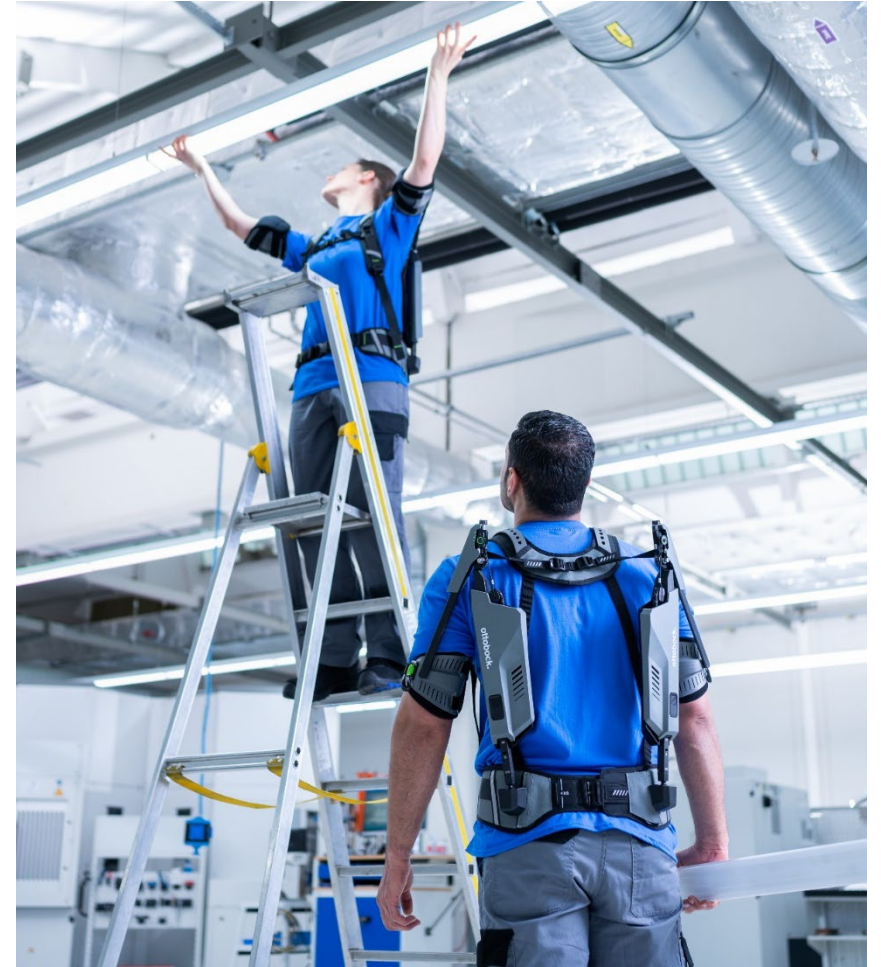


<https://www.manager-magazin.de/unternehmen/autoindustrie/daimler-betriebsrat-fordert-%20milliarden-investitionen-in-sindelfingen-a-977136.html>

Research on the adoption is mainly focused on **usability**, **effectivity** and **comfort** under lab conditions (e.g., Elprama et al., 2020; Feldmann et al., 2020)

The exoskeleton **embraces the body to relieve muscles and joints**. The **function and shape of the exoskeleton** only completely unfold **in interaction with the user's body** (Papp et al., 2020)

- How can we characterize the user experience with the exoskeletons?
- What role does **body** play in the **user experience** of occupational exoskeletons beyond ergonomics?
- What are **important experiences regarding the body** with exoskeletons beyond their functionality?





suitX.com

Sampling

Recruiting through suitX by ottobock contacts

Sample1:

Automobile Industry Assembly (IX Shoulder Air)

$N = 7$ (7 male participants)

Sample2:

Furniture Store Logistics (IX Back Air)

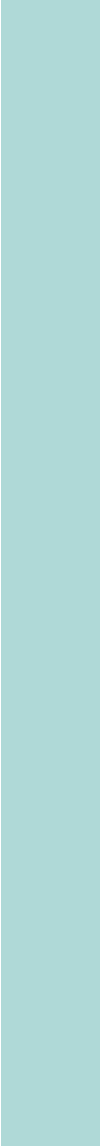
$N = 8$ (4 female, 4 male participants)

Data Collection

Semi-structured guided field interviews (face-to-face)

Analysis Via MAXQDA (v. 24.0.0)

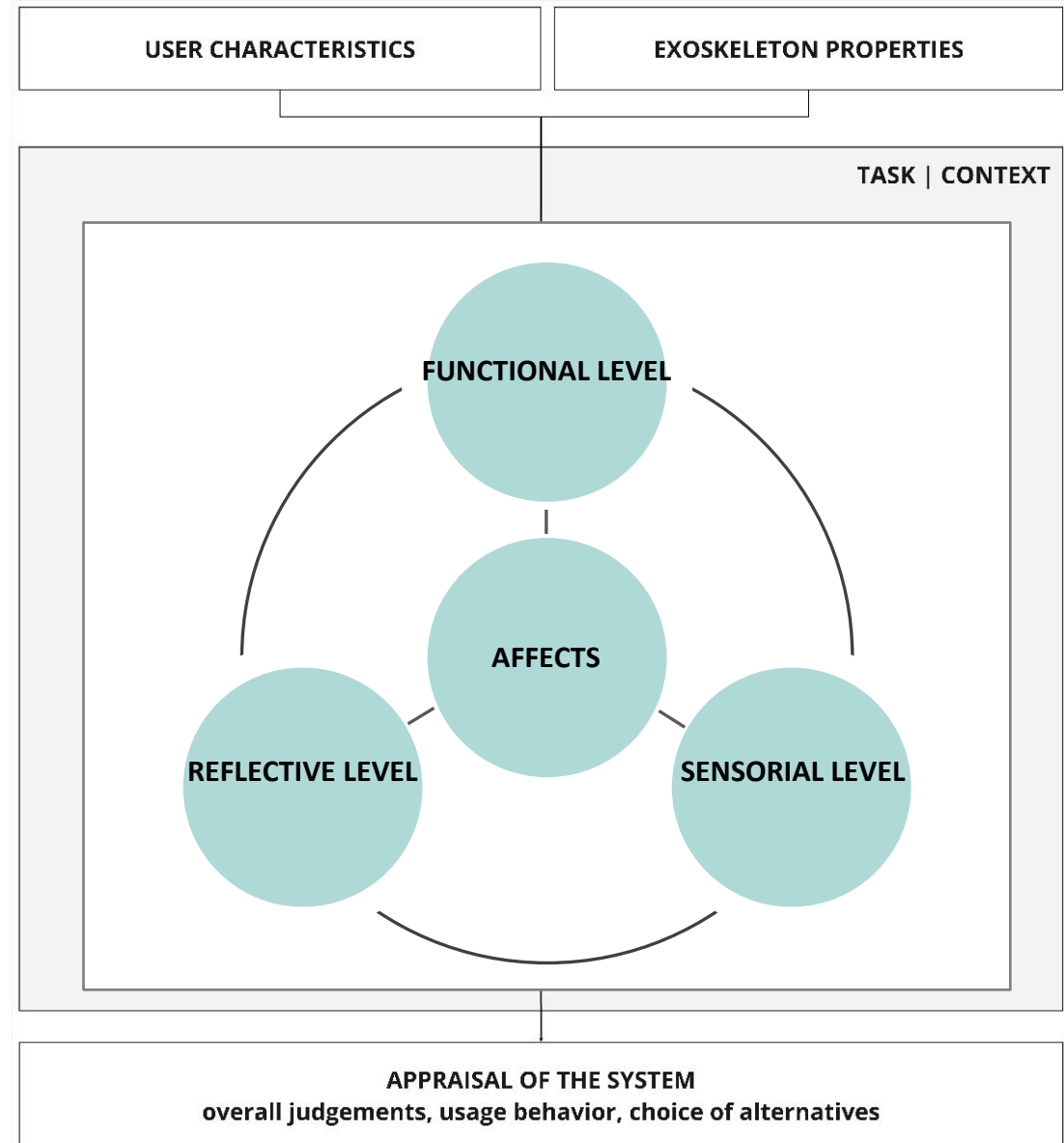
Application of a mix of deductive and inductive coding (Hsieh & Shannon, 2005)



**What do we know about
(exoskeleton) experience?**

User Experience Design focuses on **human needs** in product development. It also considers **pleasure, joy, and personal significance**, next to function, safety, and ergonomics (Hassenzahl et al., 2010; Wölfel et al., 2013).

Various factors contribute to the user experience, including **physical actions, perceptual and cognitive processes, contextual elements**, and **user characteristics** etc. (Desmet & Hekkert, 2007)



Sensorial–visceral level

immediate sensations/experiences of our sensory modalities

Functional–behavioral level

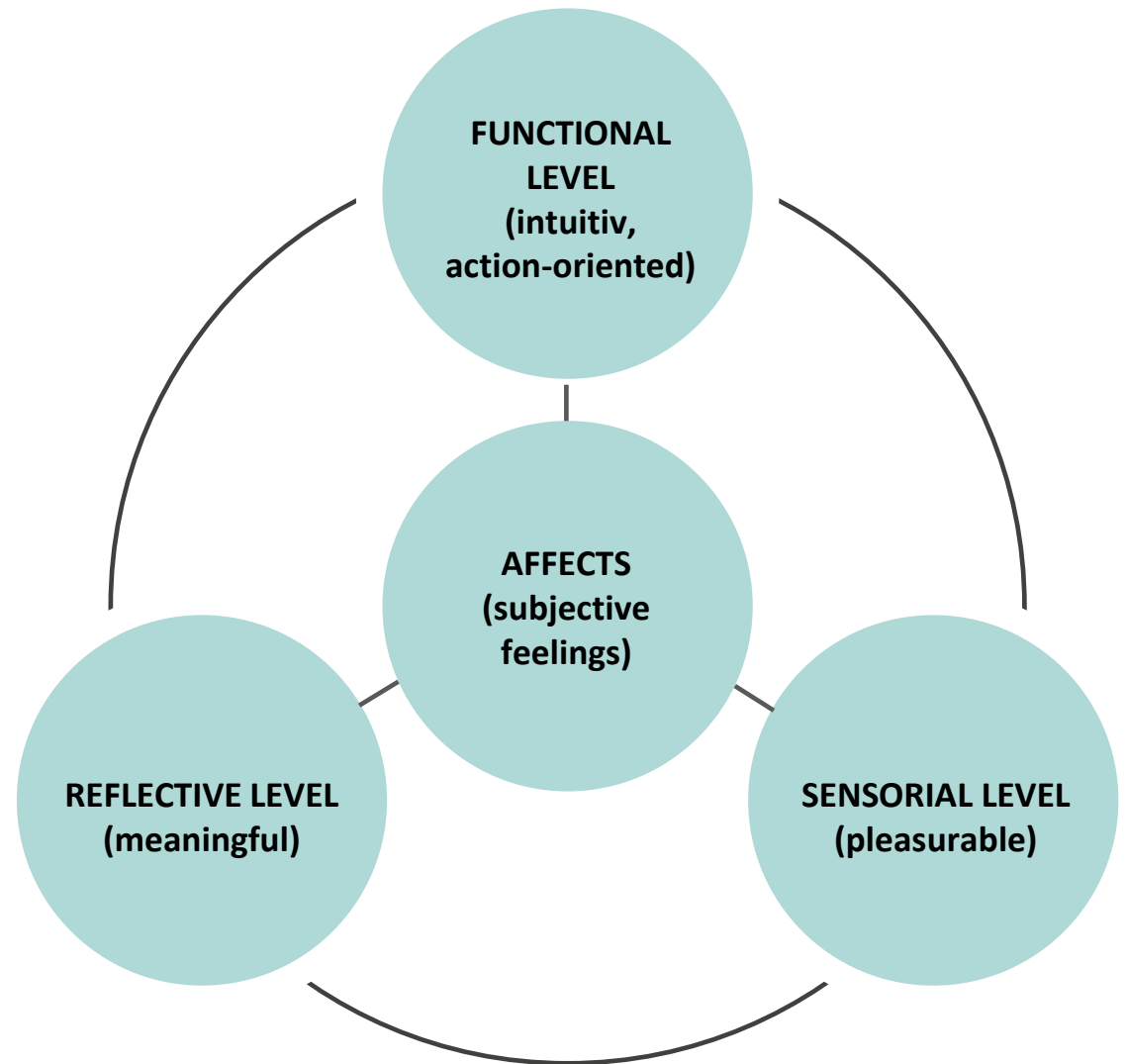
task performance, product interpretation
perceived control, mastery & intuitive and easy handling

Symbolic–reflective level

embodiment of values, Personality,
self-expression (Ludden & Van Rompay, 2015)

Affects

unconscious/conscious
subjective feelings, motor expressions



Functional–behavioral level

Good Grip (easy to hold)

Sensorial–visceral level

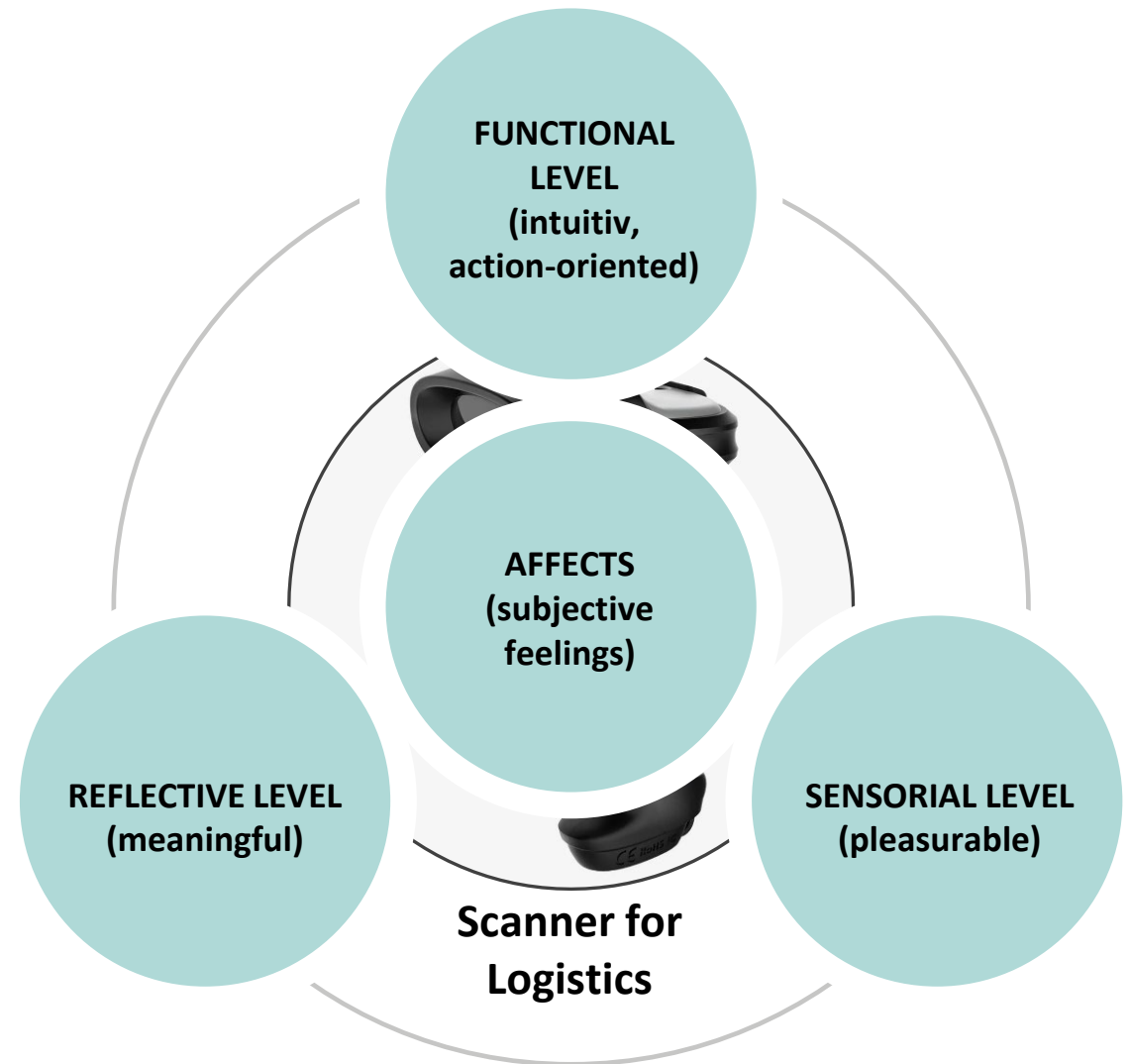
Nice haptics

Symbolic–reflective level

Professional, High-quality

Affects

Satisfaction



Functional–behavioral level

Good Grip (easy to hold)

Sensorial–visceral level

Nice haptics

Symbolic–reflective level

Professional, High-quality

Affects

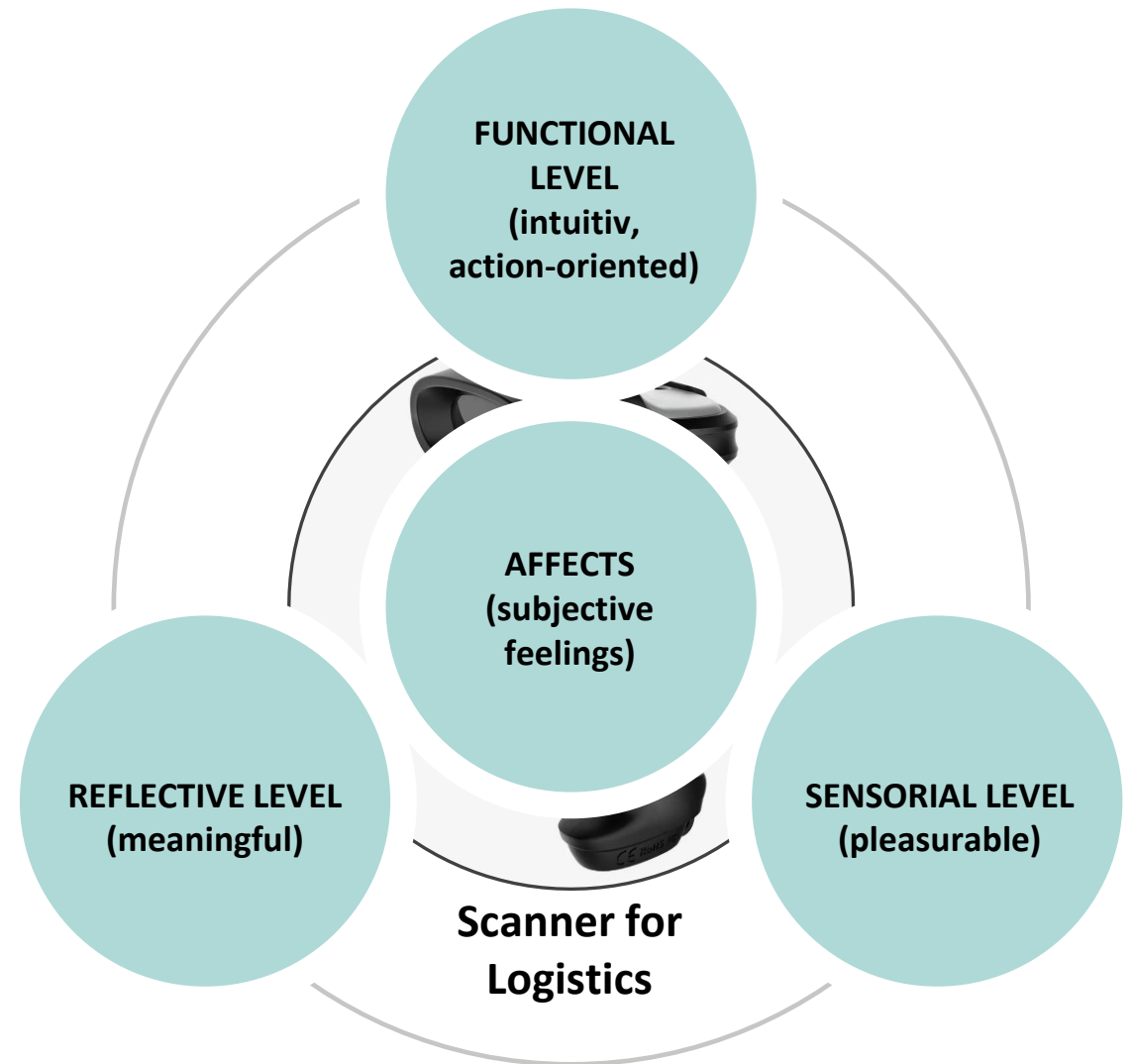
Satisfaction

Manipulating a product vs influencing of body?

How do we experience

—**technology on our body?**

—**our body through the use of technology?**



07 BODY EXPERIENCE AND IST SUBASPECTS



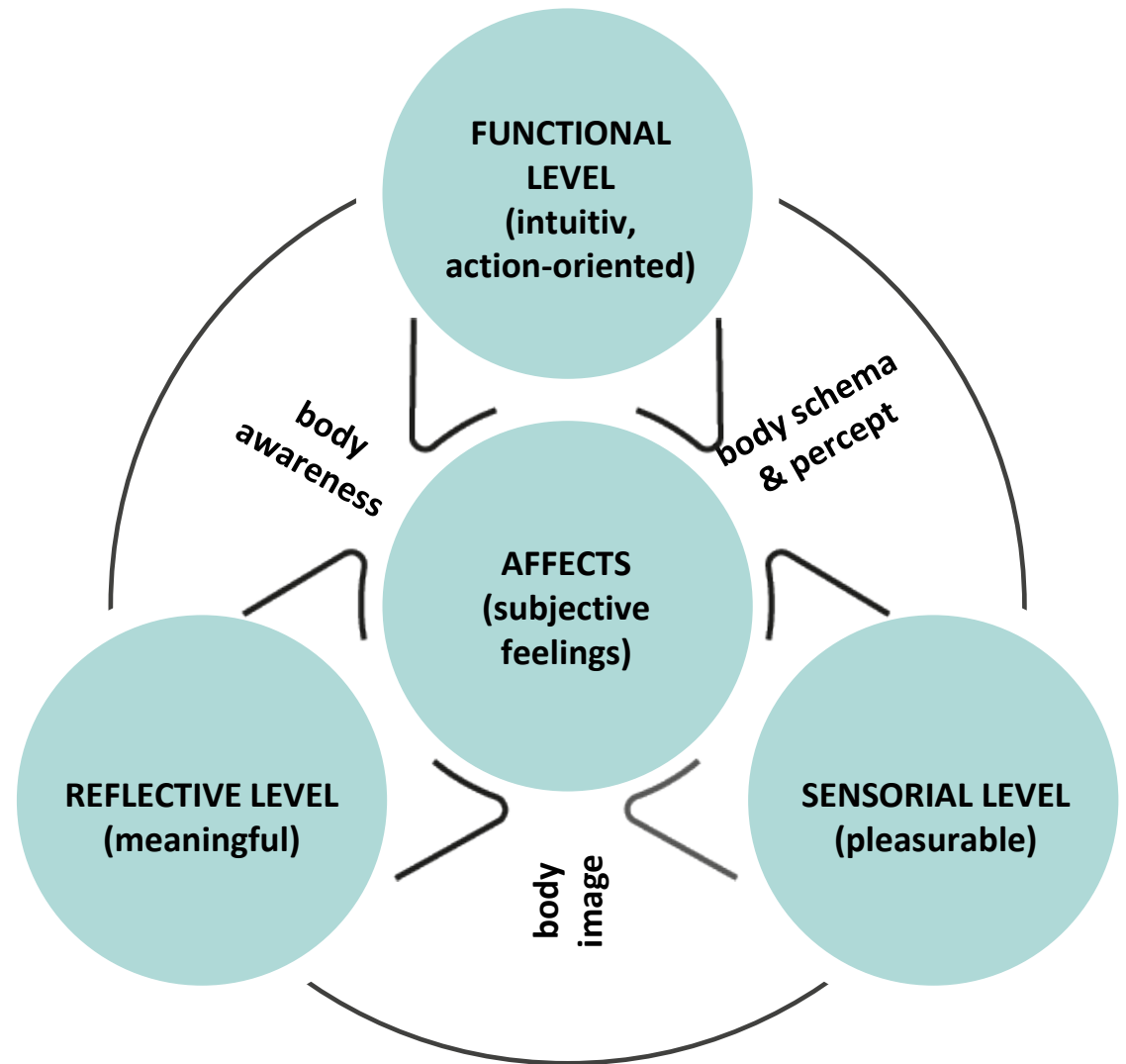
somatic pole	
subaspect	endogene information-input (stimuli)
body schema	kinaesthetic, tactile, proprioceptive stimuli
body percept	visual, auditive, thermal, olfactory, nociceptive influence
body emotions	pleasure-unpleasure feelings, biological instincts
body-ego	identity-coherence-experience
body image	experiential knowledge, learned knowledge, body-related phantasies
body awareness	body-related self-reflexions
cognitive-evaluative pole	

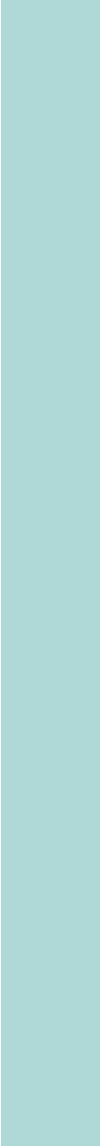
How do we experience our body?

Body Experience considers of **how individuals perceive, interpret, and interact with their bodies** through their senses **in relation to the world** around them. (Röhrich et al., 2005; Beckerle et al., 2021)

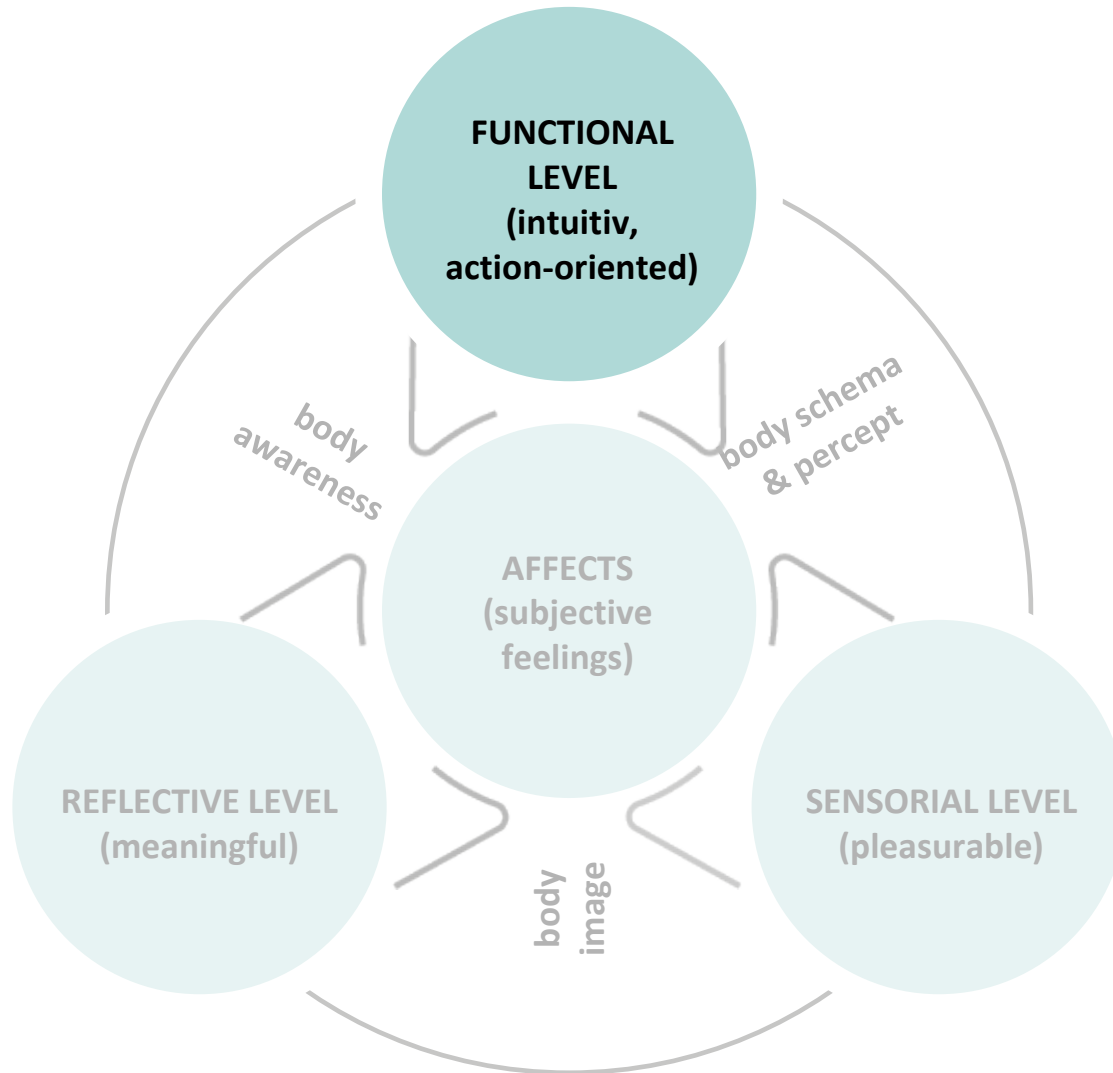
A **continuum with a somatic** and a **cognitive evaluative pole** (Röhrich et al., 2005)

Based on the established frameworks of **user experience** and the concept of **body experience**, the proposed conceptual framework (Papp et al., 2024) attempts to describe how the **exoskeleton experience unfolds** and how its **various aspects entangle themselves around the user's corporeality**.

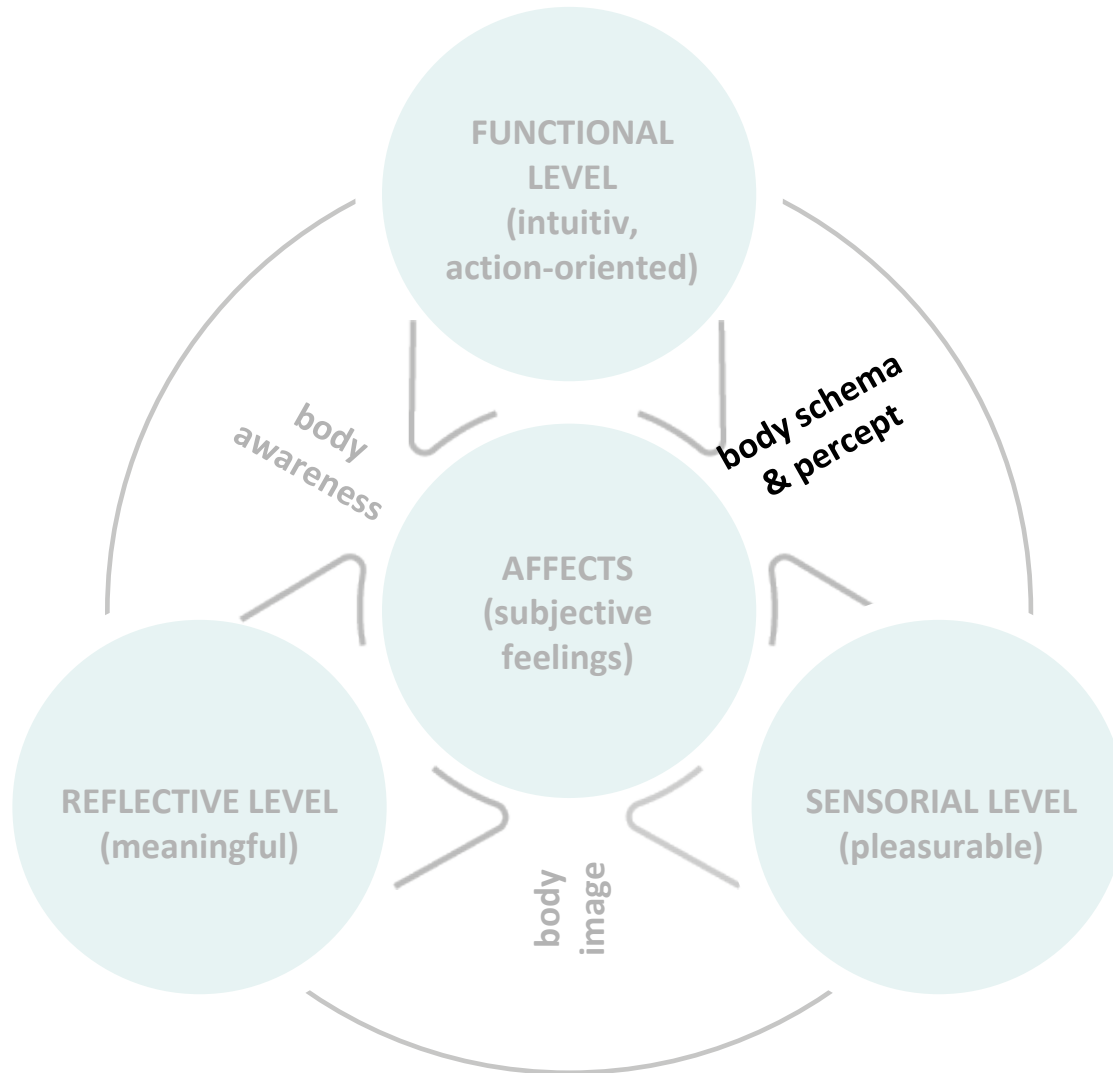




How does this model help to understand the human-exoskeleton experience?

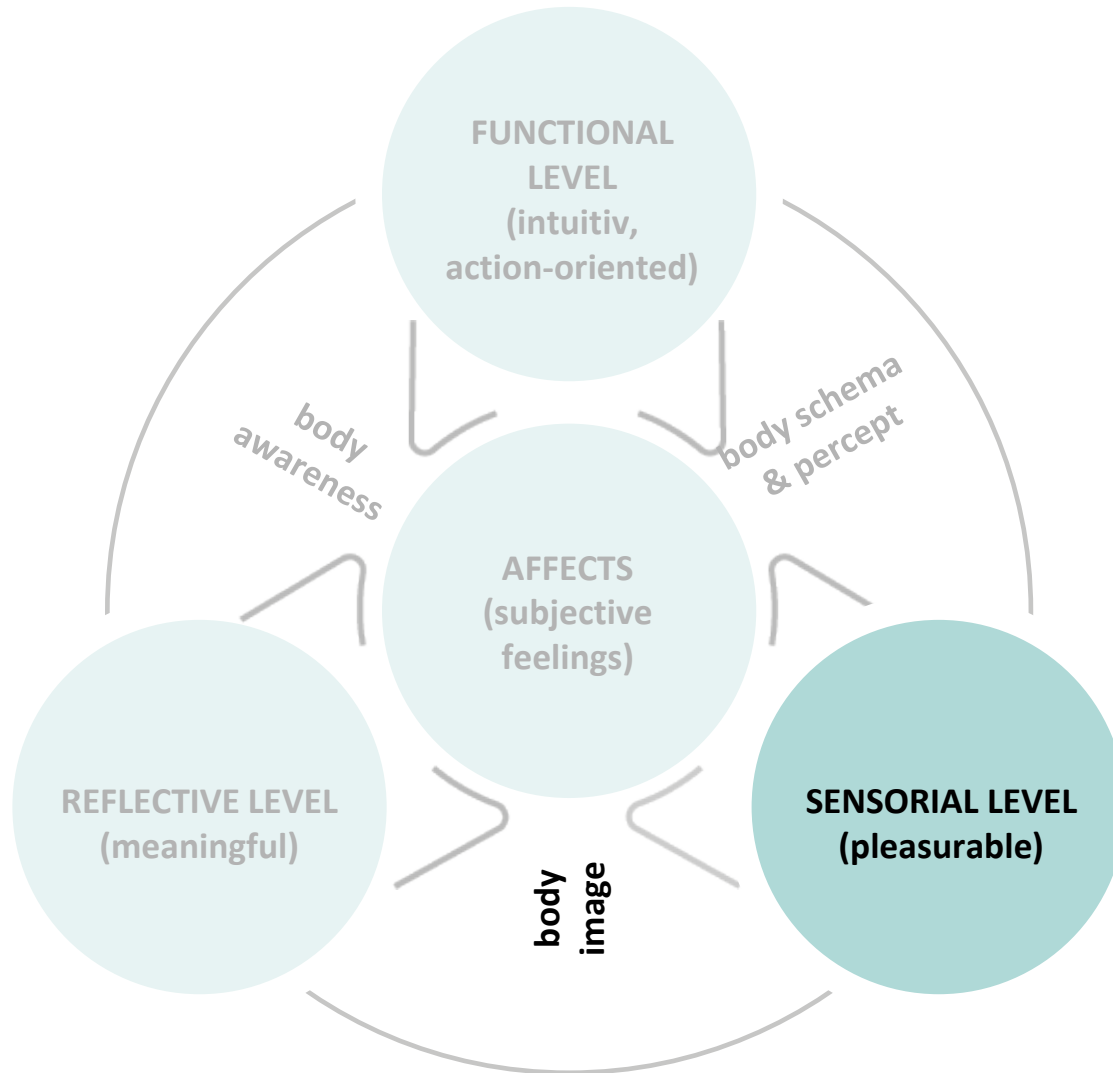


Operating principles, handling

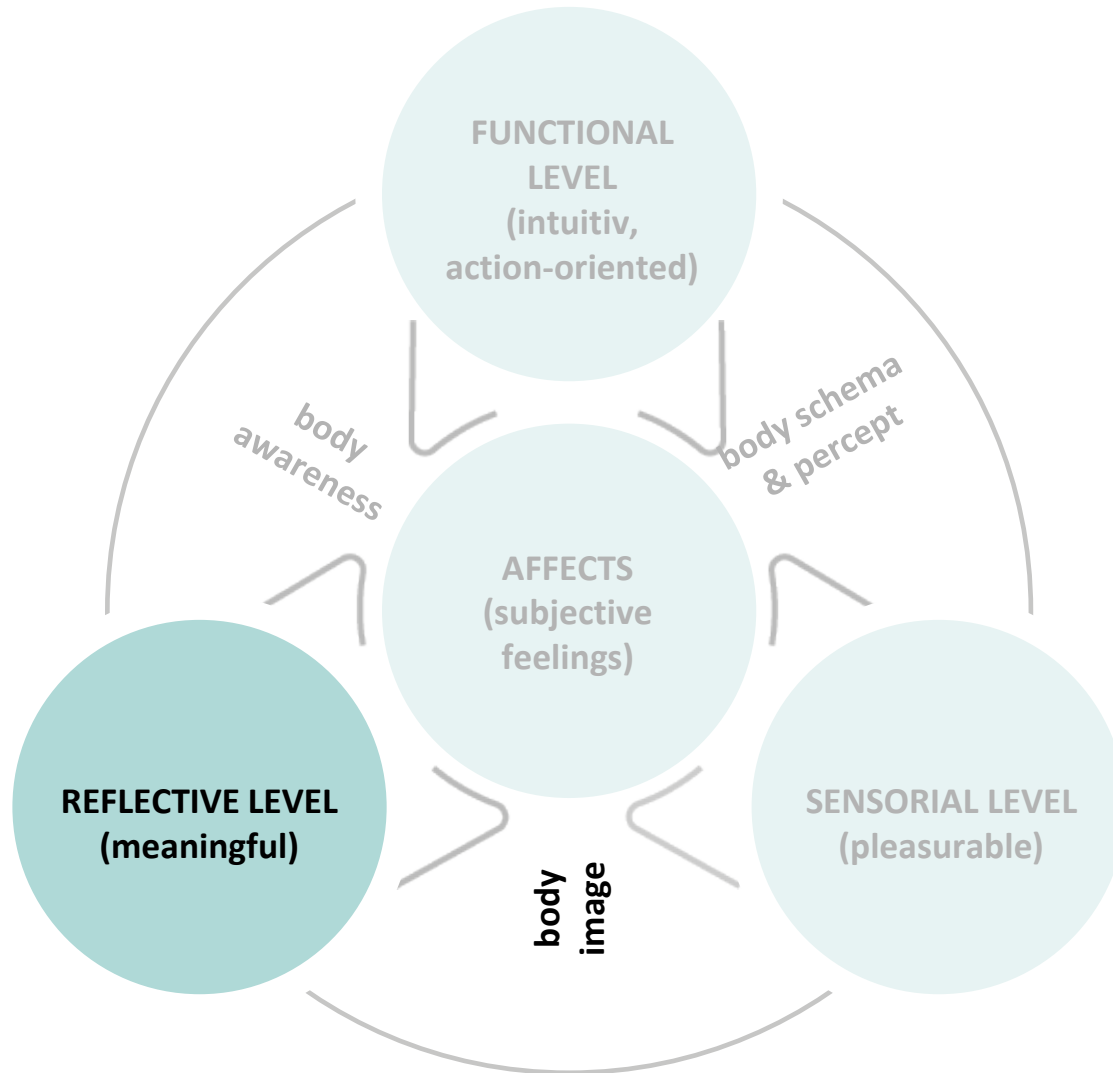


feeling in control over own body and exoskeleton (e.g. Elprama et al., 2022)

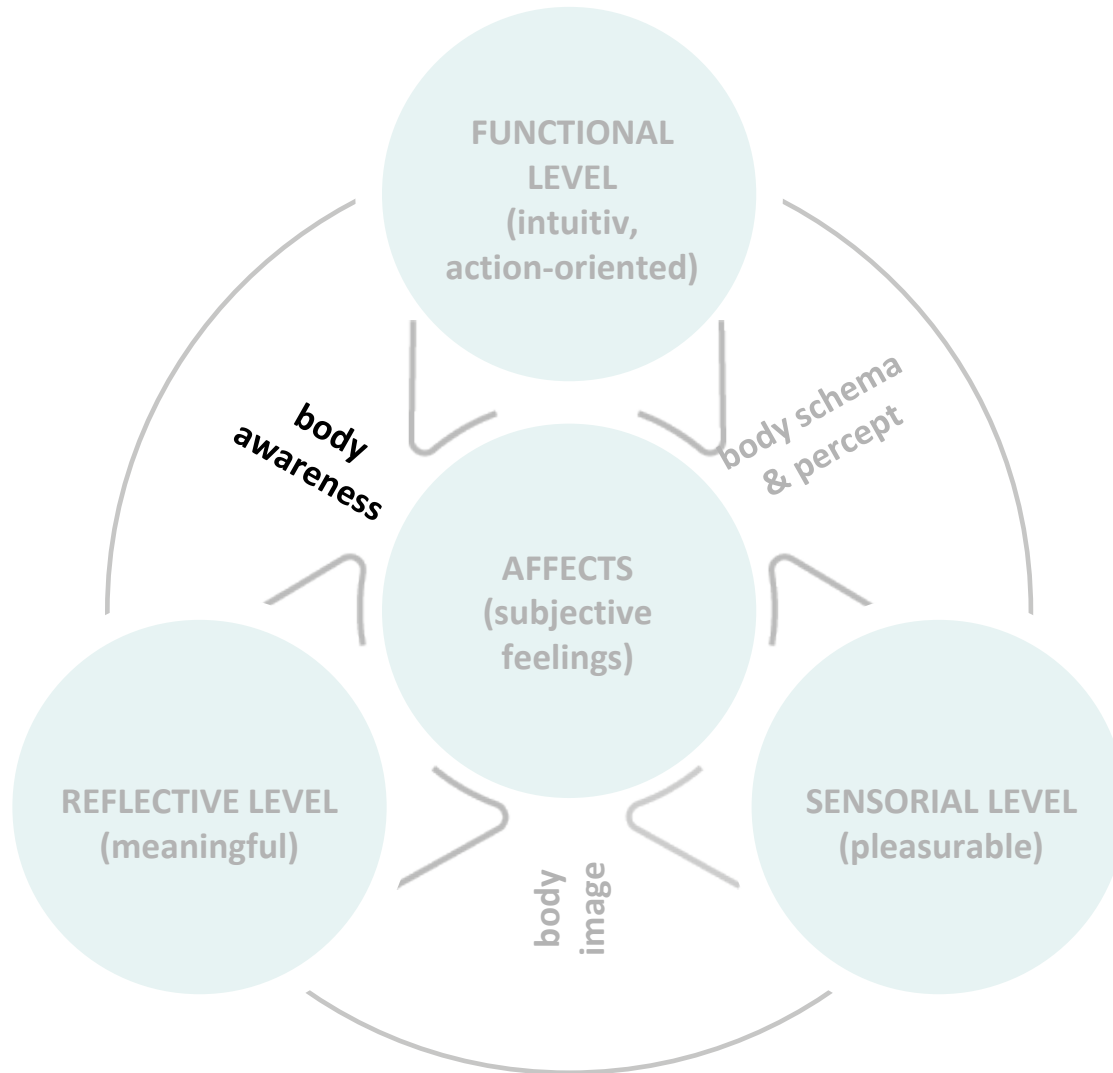
influencing the users' **body sensations**,
relieving muscles and joints



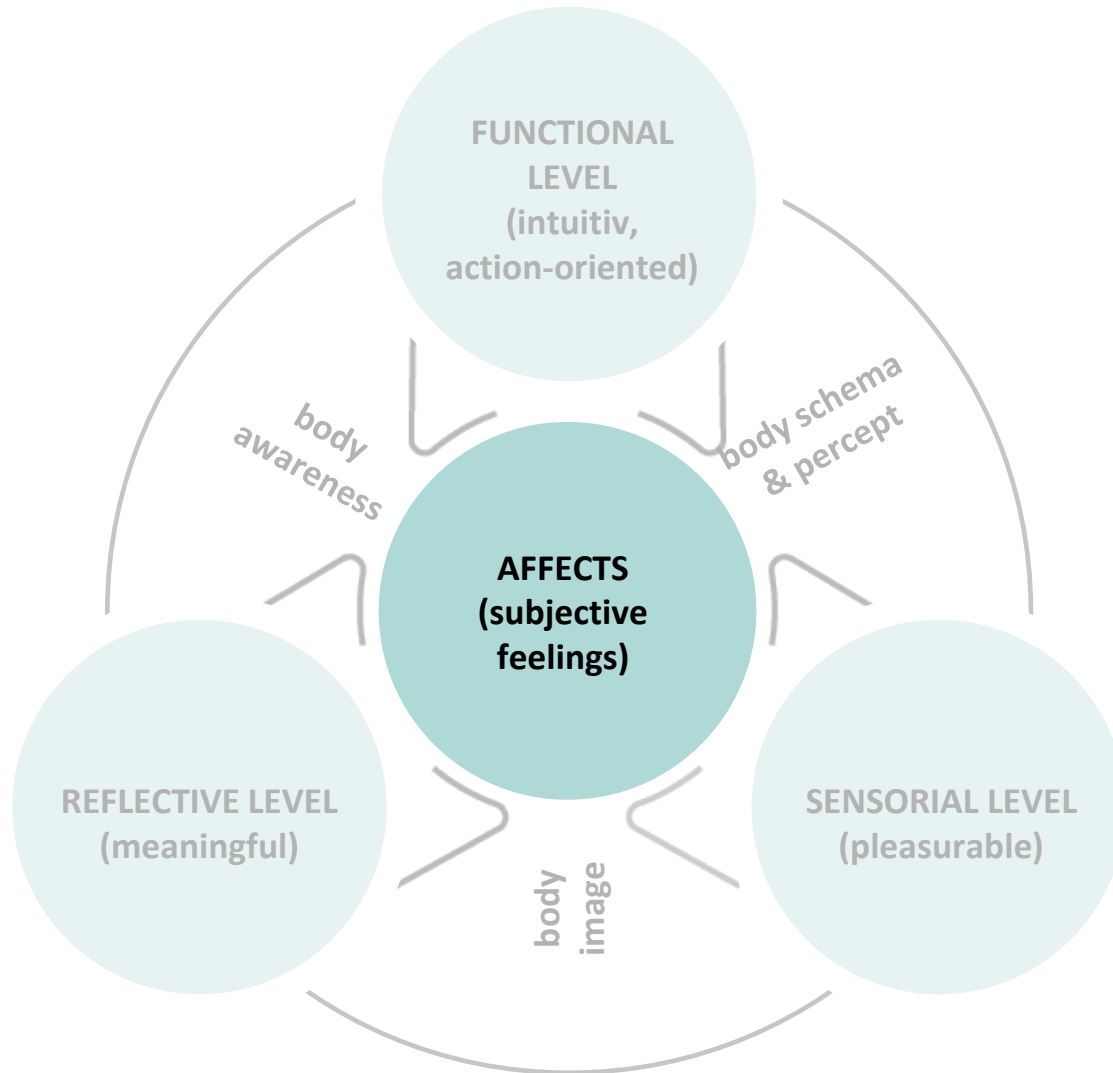
complementing the body with technical components in a **well-visible** way and **extending** the body **spatially**



influencing the user's appearance, **perception by others and self-image** (Gilotta et al., 2019; Moyon et al., 2019; Feldmann et al., 2020; Papp et al., 2020; Elprama et al., 2022)

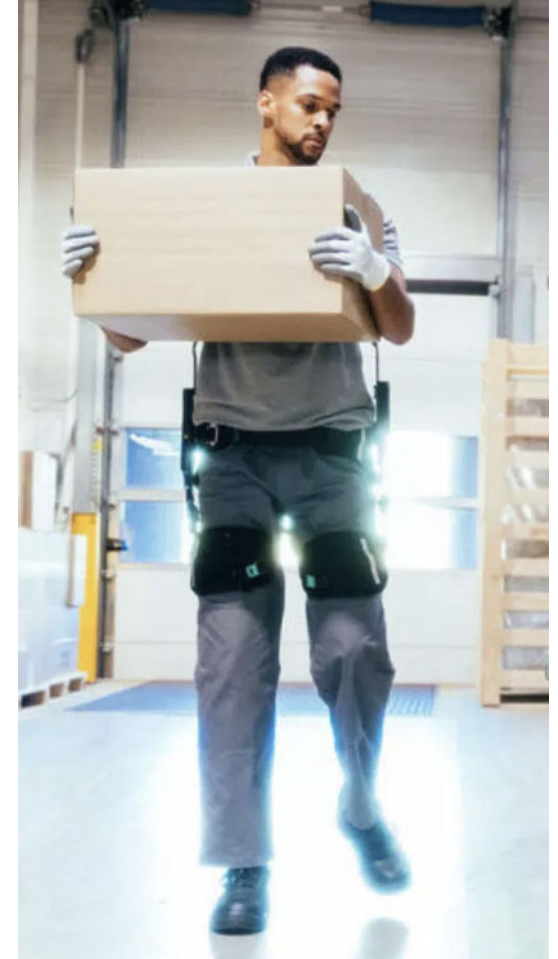


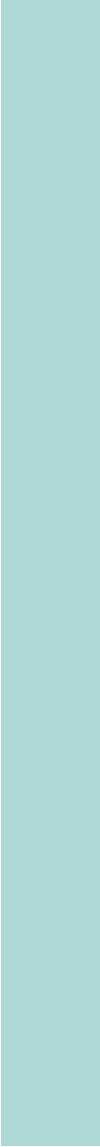
confrontation with weaknesses (Papp et al., 2020)
self-awareness (Sonneveld & Schifferstein, 2008) **kinesthetic awareness** (Jochum et al., 2018)



pleasant feeling of **vitality** (Rozendaal et al., 2017)
proud, shame

Functional Level	Force Transmission through Interface
Body Schema	Changes in Body Posture & Movement Pattern
Body Percept	(Dis)comfort, Visible & Audible Tech on the Body
Sensorial Level	
Body Image	Moving & Looking like „Terminator“
Reflective Level	
Body Awareness	Exo 's Influences on Body (pos./neg.)





**What are frequently mentioned topics
in relation bodily aspects?**

**How are these topics connected to reflective level
or meaningful experiences?**

Self-Efficacy: Taking Control of Own Health (Body Awareness)

Staying healthy and working shouldn't be mutually exclusive. Potential for exoskeletons to convey the **sense of empowerment** and help **proactive health management**.

More positive attitude towards work (Body Percept & Body Schema)

Exoskeletons instill a sense of **reduced physical strain**, leading to decreased stress (not increased performance) and a more positive attitude towards work and increased motivation for certain tasks.



https://logistra.de/sites/default/files/public/styles/_news_1050x700_public/images-news-teaser/hermes-germany-exoskelett-im-einsatz-bei-grossstuecksortierung.jpg

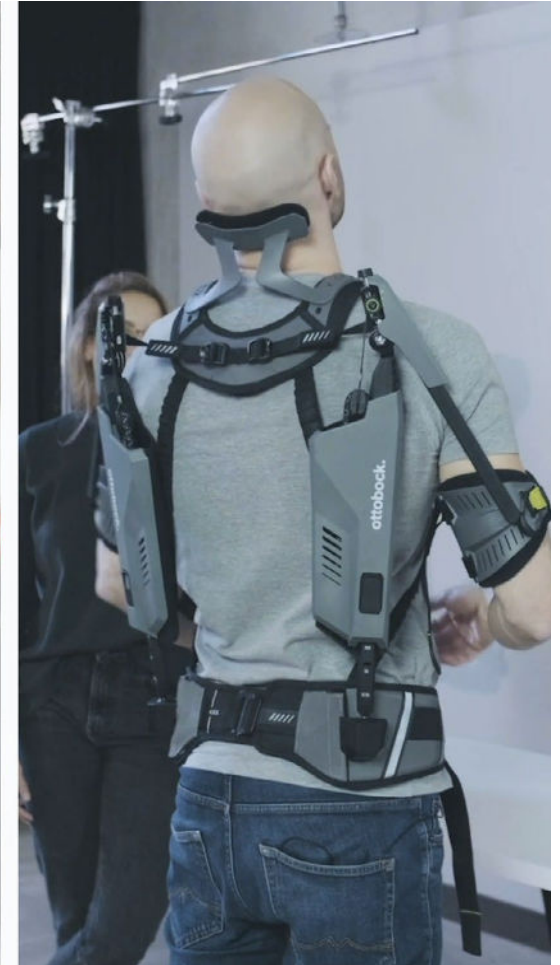
EXO EXPERIENCES – VISUAL APPEARANCE AS EMBODIMENT OF VALUES (BODY IMAGE)

Robots as a Dichotomous Reference due to limited references: Users liken the exoskeleton to Robocop, reflecting both fascination (**futuristic, cool**) and reservation (**unrefined or machine-like**).

Visual Aesthetics - PINK is the New Black Sheep

Users struggle to articulate design opinions, suggesting limited exposure to exoskeletons and design topics „as long as the exo is not pink, I can wear it“

But, user can **appreciate design** (improvements), when they have **referencies**.



Being Part of Organizational Change (Body Image)

Users assume their role in demonstrating progress: The exoskeleton serves as a bridge to organizational change and future applications. Trying out new technologies can create a sense of **competence**. (This could be emphasized by high-tech and futuristic design).

Sharing Experiences (Body Awareness, Body Image)

Despite initial teasing, the exoskeleton arouses the interest of most colleagues, prompting the user to share their knowledge. Through this exchange, the user can experience the feeling of **connectedness**.



- Our findings emphasize that the **human-exoskeleton experience should be viewed in its entirety**, encompassing how it affects users' body, their relationship with their own bodies, and their self-perception, as the **user experience entangling with the user's corporeality**.
- The conceptual **Framework of Exoskeleton Experience** (Papp et al., 2024), which is based on the established model of **user experience** and concept **body experience**, provides a **good orientation** in the study of the human-exoskeleton experience, although it needs to be reviewed after the final analysis of our qualitative study.
- **Guidelines for Positive User Experience:** Developers are encouraged to design exoskeletons that cater to diverse body capabilities and promote positive experiences by considering the intricate needs of users.
- **Interdisciplinary Collaboration** could advance the consideration of human well-being in physical, cognitive, and emotional realms when developing exoskeleton technology.
- Development of **Systematic Assessment Scale** considering User Experience

THANK YOU FOR YOUR ATTENTION!
DO YOU HAVE ANY QUESTIONS?

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