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Abstract

Human Augmentation Technologies (HATs) can improve, restore, or enhance a person's abilities. For instance, bionic prostheses or exoskeletons in manufacturing are examples of such devices that are likely to become more widespread. This development raises concerns about how merging human bodies with technology will affect people psychologically and socially. For instance, how will it affect the way non-users view users, and how will it affect users' self-perceptions? According to studies based on the Stereotype Content Model, the technical capabilities of these technologies will influence how others evaluate their users in terms of Warmth and Competence. However, research on the impact of these technologies is limited, and until now, there is no research on how they affect the self-perception of their users.

This dissertation aims to gain a deeper understanding of the psychological effects of HAT usage. It provides more empirical evidence on their influence on social perception and explicitly addresses the user's perspective.

To broaden the relatively scarce existing knowledge and to shed more light on users' self and meta-perception, a mixed methods approach, including three empirical studies, is employed. Two experimental studies (N_1 = 459, N_2 = 338) on the social perception of users of human augmentation technologies were conducted. The findings were supplemented with a qualitative study to account for the underexposed user perspective. Within ten semi-structured interviews with expert users of bionic arm prostheses, they provided crucial insights into their self-perception and how they believe others see them.

Study 1, Embodied Digital Technologies: First Insights in the Social and Legal Perception of Robots and Users of Prostheses, focuses mainly on the social perception of (bionic) prosthesis users and different types of robots. Regarding HATs, findings indicate that

users of low-tech prostheses were perceived as significantly less competent than users of high-tech prostheses and non-disabled individuals. Counterintuitively, we found no differences between users of low- or high-tech prostheses and non-disabled individuals in terms of attributed Sociability, whereas attributions of Morality were higher for users of both low- and high-tech prostheses. In sum, the study provides evidence for HATs' influence on social perception insofar as the type of prosthesis or the level of technicality matters in evaluating their users.

Study 2, Social Perception of Embodied Digital Technologies - A Closer Look at Bionics and Social Robotics, aims to gain a deeper understanding of how fundamental principles of social perception impact the development of attitudes towards HAT users and social robots. This study also examines how people perceive users of different prostheses and robots, focusing on their Competence, Sociability, and Morality. Users of low-tech prostheses were attributed less Competence than non-disabled individuals, but they did not differ from users of high-tech prostheses. However, users of high-tech prostheses were evaluated as competent as non-disabled persons. Once more, Sociability did not differ between people with and without disabilities. Nonetheless, Morality did: Users of low-tech prostheses were perceived as more moral than users of high-tech prostheses or non-disabled individuals, who did not differ.

Study 3, The Impact of Bionic Prostheses on User´s Self-Perceptions: A Qualitative Study, aims to obtain insights into the self- and meta-perceptions of HAT users. The study's results indicate that using bionic prostheses influences social (self-)perception in multiple ways. Users describe themselves as being seen as more competent by others and treated differently after receiving the bionic prosthesis in comparison to simpler models. Also, users report feeling more confident and experiencing higher levels of self-efficacy.

Resuming, despite their somewhat mixed nature, the findings derived from the above-mentioned studies imply that using human augmentation technologies (i.e., bionic prostheses) affects not only users' self-perceptions but also stereotypes and interpersonal perceptions. However, despite their inclusive potential and mainly positive effects on social perceptions, results also show that introducing such technologies in future (work) contexts might have unintended social repercussions that must be accounted for.

Consequently, potential strategies for mitigating such unwanted side effects are discussed, implications for future research are derived, and an outlook on upcoming studies is given.

Keywords: social perception, human augmentation technologies, stereotypes, self- and other perception, social interaction

Zusammenfassung

Technologien zur Augmentierung des menschlichen Körpers (Human Augmentation Technologies; HATs) können die Fähigkeiten einer Person verbessern, wiederherstellen oder erweitern. Bionische Prothesen oder Exoskelette in der Fertigung sind Beispiele für solche Systeme, die sich wahrscheinlich weiterverbreiten werden. Diese Entwicklung wirft die Frage auf, wie sich die Verschmelzung des menschlichen Körpers mit Technologie auf Menschen psychologisch und sozial auswirken wird. Wie wird sich dies beispielsweise auf die Art und Weise auswirken, wie Nichtnutzer:innen die Nutzer:innen sehen, und wie wird es die Selbstwahrnehmung der Nutzer:innen beeinflussen? Studien, die sich auf das Stereotype Content Model stützen, zeigen, dass die technischen Möglichkeiten dieser Systeme einen Einfluss darauf haben werden, wie andere ihre Nutzer:innen in Bezug auf Wärme und Kompetenz einschätzen. Diese Auswirkungen sind jedoch nur in begrenztem Maße erforscht und bis jetzt gibt es keine Untersuchungen darüber, wie HATs sich auf die Selbstwahrnehmung ihrer Nutzer:innen auswirken.

Diese Dissertation zielt darauf ab, ein tieferes Verständnis der psychologischen Auswirkungen der HAT-Nutzung zu erlangen, indem sie mehr empirische Belege für ihren Einfluss auf die soziale Wahrnehmung liefert und explizit die Perspektive von Nutzer:innen berücksichtigt.

Zur Erweiterung des relativ geringen vorhandenen Wissens und um mehr Licht auf die Selbst- und Metawahrnehmung der Nutzer:innen zu werfen, wird ein Mixed-Methods-Ansatz verwendet, der drei empirische Studien umfasst. Konkret wurden zwei experimentelle Studien (N_1 = 459, N_2 = 338) zur sozialen Wahrnehmung von Nutzer:innen entsprechender Augmentationstechnologien durchgeführt. Die damit verbundenen Erkenntnisse wurden durch

eine qualitative Studie ergänzt, um die bisher vernachlässigte Nutzer:innenperspektive zu berücksichtigen. In zehn halbstrukturierten Interviews mit erfahrenen Nutzer:innen bionischer Armprothesen konnten wir entscheidende Erkenntnisse über deren Selbst- und Fremdwahrnehmung gewinnen.

Studie 1, "Embodied Digital Technologies: First Insights in the Social and Legal Perception of Robots and Users of Prostheses", konzentriert sich hauptsächlich auf die soziale Wahrnehmung von (bionischen) Prothesenträger:innen und verschiedenen Arten von Robotern. In Bezug auf HATs deuten die Ergebnisse darauf hin, dass Benutzer:innen von Low-Tech-Prothesen als deutlich weniger kompetent wahrgenommen werden als Benutzer:innen von High-Tech-Prothesen und Personen ohne Behinderung. Überraschenderweise fanden wir keine Unterschiede zwischen Nutzer:innen von Low- oder High-Tech-Prothesen und Personen ohne Behinderung in Bezug auf die zugeschriebene Umgänglichkeit (Sociability), während die Zuschreibung von Moral (Morality) sowohl bei Nutzer:innen von Low- als auch von High-Tech-Prothesen höher war. Insgesamt liefert die Studie Belege für den Einfluss von HATs auf die soziale Wahrnehmung, da die Art der Prothese oder der Grad der Technisierung bei der Bewertung ihrer Nutzer:innen eine Rolle spielt.

Studie 2, Social Perception of Embodied Digital Technologies - A Closer Look at Bionics and Social Robotics, zielt darauf ab, ein tieferes Verständnis dafür zu erlangen, wie grundlegende Prinzipien der sozialen Wahrnehmung die Entwicklung von Einstellungen gegenüber Nutzer:innen von HATs und sozialen Robotern beeinflussen. In dieser Studie wird auch untersucht, wie die Menschen die Benutzer:innen verschiedener Prothesen und Roboter wahrnehmen, wobei der Schwerpunkt auf deren Kompetenz, Umgänglichkeit (Sociability) und Moral (Morality) liegt. Den Nutzer:innen von Low-Tech-Prothesen wurde weniger Kompetenz

zugeschrieben als Personen ohne Behinderung, sie unterschieden sich diesbezüglich jedoch nicht von den Nutzer:innen von High-Tech-Prothesen. Die Nutzer:innen von High-Tech-Prothesen wurden jedoch genauso kompetent eingeschätzt wie Personen ohne Behinderung. Auch bei der Umgänglichkeit (Sociability) gab es keine Unterschiede zwischen Menschen mit und ohne Behinderung. Hingegen zeigte sich ein Unterschied bei der Einschätzung der Moralität (Morality): Nutzer:innen von Low-Tech-Prothesen wurden als moralischer wahrgenommen als Nutzer:innen von High-Tech-Prothesen oder Personen ohne Behinderung.

In Studie 3, The Impact of Bionic Prostheses on User´s Self-Perceptions: A Qualitative Study, sollten Erkenntnisse über die Selbst- und Metawahrnehmung von HAT-Nutzer:innen gewonnen werden. Die Ergebnisse unserer qualitativen Analyse deuten darauf hin, dass die Verwendung bionischer Prothesen die soziale (Selbst-)Wahrnehmung in mehrfacher Hinsicht beeinflusst. So beschreiben die Nutzer:innen, dass sie von anderen als kompetenter angesehen und anders behandelt werden, seitdem sie eine bionische Prothese erhalten haben, im Vergleich zur vorherigen Nutzung von einfacheren Prothesen-Modellen. Außerdem berichteten die Nutzer:innen, dass sie sich selbstbewusster fühlten und ein höheres Maß an Selbstwirksamkeit empfänden.

Zusammenfassend lässt sich sagen, dass die Erkenntnisse der oben genannten Studien trotz ihrer etwas uneinheitlichen Ergebnisse darauf hindeuten, dass der Einsatz menschlicher Augmentations-Technologien (d. h. bionischer Prothesen) nicht nur die Selbstwahrnehmung der Nutzer, sondern auch Stereotypen und zwischenmenschliche Wahrnehmungen beeinflussen. Ungeachtet ihres integrativen Potenzials und ihrer überwiegend positiven Auswirkungen auf die soziale Wahrnehmung zeigen die Ergebnisse jedoch auch, dass die Einführung solcher

Technologien in künftigen (Arbeits-)Kontexten unbeabsichtigte soziale Auswirkungen haben könnten, denen Rechnung getragen werden muss.

Folglich werden potentielle Strategien zur Abmilderung solcher unerwünschten Nebeneffekte diskutiert, Implikationen für die zukünftige Forschung abgeleitet und ein Ausblick auf kommende Studien gegeben.

Stichworte: Soziale Wahrnehmung, Human Augmentation Technologies, Stereotype, Selbst- und Fremdwahrnehmung, Soziale Interaktion

I. SYNOPSIS

1 Introduction

Technology is constantly advancing, and digital tools are becoming more prevalent in modern societies. These changes profoundly impact almost every aspect of our everyday lives. Against this background, an increasing prevalence of Human Augmentation Technologies (HATs)[1], devices that are close to the human body and can restore, improve, or enhance human sensory, cognitive, or motor abilities (Raisamo et al., 2019; Villa, Niess, Nakao et al., 2023; Villa, Niess, Schmidt et al., 2023), is observable. Such devices are likely to become even more prevalent soon, and their proliferation has the potential to fundamentally alter the way we live and work, as they are likely to affect how users and non-users of such technologies perceive each other and interact with each other (B. Meyer & Asbrock, 2018).

Today, technologies for reestablishing or augmenting users' motor capabilities (e.g., bionic prostheses or exoskeletons in manufacturing) are the most prominent applications of such technologies. Despite the ongoing dissemination and increasing number of articles and books on human augmentation and HATs' societal opportunities and risks, more is needed to know about its acceptance. This raises questions about the psychological and social consequences of merging human bodies with technologies, including whether the utilization of HATs engenders a differential treatment of users compared to non-users and how it influences the psychological processes of self- and other-perceptions.

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[1] In this dissertation, the more precise term Human Augmentation Technologies (HATs) is used instead of Embodied Digital Technologies (EDTs), initially used in the underlying publications. A discussion and classification of the terminology is provided in section 2.1.

However, despite these pressing research questions, until recently, research on the effects of HATs on self- and other-perceptions (e.g., on the acceptance of HAT users) was scarce, has been technical in nature, and has not addressed the social implications of these technologies in depth. Prior research shows that people with physical disabilities are perceived as warm and incompetent, leading to pity and active facilitation (Asbrock, 2010; Fiske et al., 2002; B. Meyer & Asbrock, 2018). In contrast, recent results indicate that bionic prosthesis users are perceived as warm and competent, reclaiming Competence while retaining Warmth (B. Meyer & Asbrock, 2018).

Overall, the existing research implies that bionics or restorative motor HATs, respectively, can profoundly affect the social perception of their users, such that they are perceived differently in terms of Warmth and Competence (B. Meyer & Asbrock, 2018). Accordingly, using (restorative motor) HATs is likely to affect attitudes and behaviors toward their users as well as how HAT users perceive themselves.

Prior research focused on how these devices affect others' perceptions of their users. However, more research is needed to understand how they affect users' self-image and perception, as the corresponding theory is scarce. Consequently, the present research aims to gain more profound insights into how restorative bionic devices influence social perception and users' self-perceptions. The primary aim is to shed more light on the influence of using such technologies on fundamental dimensions of social perception and behavioral consequences and the user's self-perception, meta-perception, and everyday experiences in social interactions. For two noteworthy reasons, this dissertation focuses on augmentation technologies for restoring human motor capabilities (i.e., bionic prostheses). As mentioned above, (restorative) motor HATs are currently the most common application, and they are most likely to proliferate in

everyday encounters soon. Secondly, these HATs come with extensive, inclusive potential for their users on the one hand and might lead to stigmatization on the other. So, it is essential to research the social consequences of using such technology (Gilotta et al., 2019; Villa, Niess, Schmidt et al., 2023). Given that, it is inevitable to understand user perceptions, corresponding attributions, evoked feelings, and behavioral correlates, especially when it comes to accepting users of human augmentation technologies on a broader societal level.

Three empirical studies were conducted as part of this dissertation to realize these insights and to contribute to a deeper understanding of the underlying psychological processes. These studies are based on the Stereotype Content Model (SCM; Fiske et al., 2002) and its extension by the Behaviors from Intergroup Affects and Stereotypes Map (BIAS Map; Cuddy et al., 2007) as a central theoretical frame of reference.

In the upcoming section, the theoretical background and core terms are explained. Subsequently, the conducted studies are summarized, the results are discussed, and finally reflected in a concluding section.

2 Theoretical Background

This section will clarify the terms and explain the theoretical background used in this dissertation. First, it will discuss why the concept of Human Augmentation Technologies is used instead of Embodied Digital Technologies, which are referred to in the original publications on which this dissertation is based. Second, an introduction to Social Perception Research and its specific application is provided to ensure the reader's understanding of the fundamental theoretical terms and concepts.

2.1 From Embodied Digital Technologies to Human Augmentation Technologies

The term Embodied Digital Technologies (EDTs) was first coined within the Collaborative Research Center 1410 "Hybrid Societies: Humans Interacting with Embodied Digital Technologies" to differentiate between unembodied technologies (e.g., chatbots) and embodied technologies (e.g., robots). According to Mandl (2024), on a fundamental level, EDTs are physically present technologies that can interact with one another or with humans. Beyond this basal definition, a more illustrative description is given below:

> Digital technologies that gain autonomy and meet humans in more and more places in various physical forms, for instance as self-driving vehicles, robots, and drones, but also as avatars and other smart agents with virtual bodies. Digital technologies do also connect more often to the human body as digitally augmented prosthetics, exoskeletons, and virtual reality goggles, for example. Such technologies are embodied digital technologies (EDTs). (DFG, n.d., Project Description section)

Given that this dissertation is based on a research collaboration within the CRC 1410, its empirical studies used the term EDTs while combining different foci (e.g., bionic prostheses and robots). Despite its undoubted usefulness for interdisciplinary research collaboration, the necessarily broad category of EDTs comes at the price of insufficient precision and a need for internal and external distinctiveness.

Concerning EDTs, S. Meyer et al. (2023) pointed out that it is crucial to elaborate on which technology and context the specific research focuses to ensure clarity. Moreover, recent research has shown that when humans integrate technology with their bodies, such as using bionic prostheses, they are still perceived as humans. All human definitions still apply to them (Mandl, 2024; S. Meyer et al., 2023). These findings suggest that technologies connected to

human bodies are different from other technologies, such as robots, that are functional on their own or capable of acting autonomously, like self-driving cars.

Consequently, it is appropriate to use a more precise terminology to establish clear boundaries between humans using technology, technology mimicking humans, and technologies with some form of "body". The significant distinction between humans using technology and other forms subsumed under the umbrella term EDT is that human action is core, and augmenting technologies supports human actions.

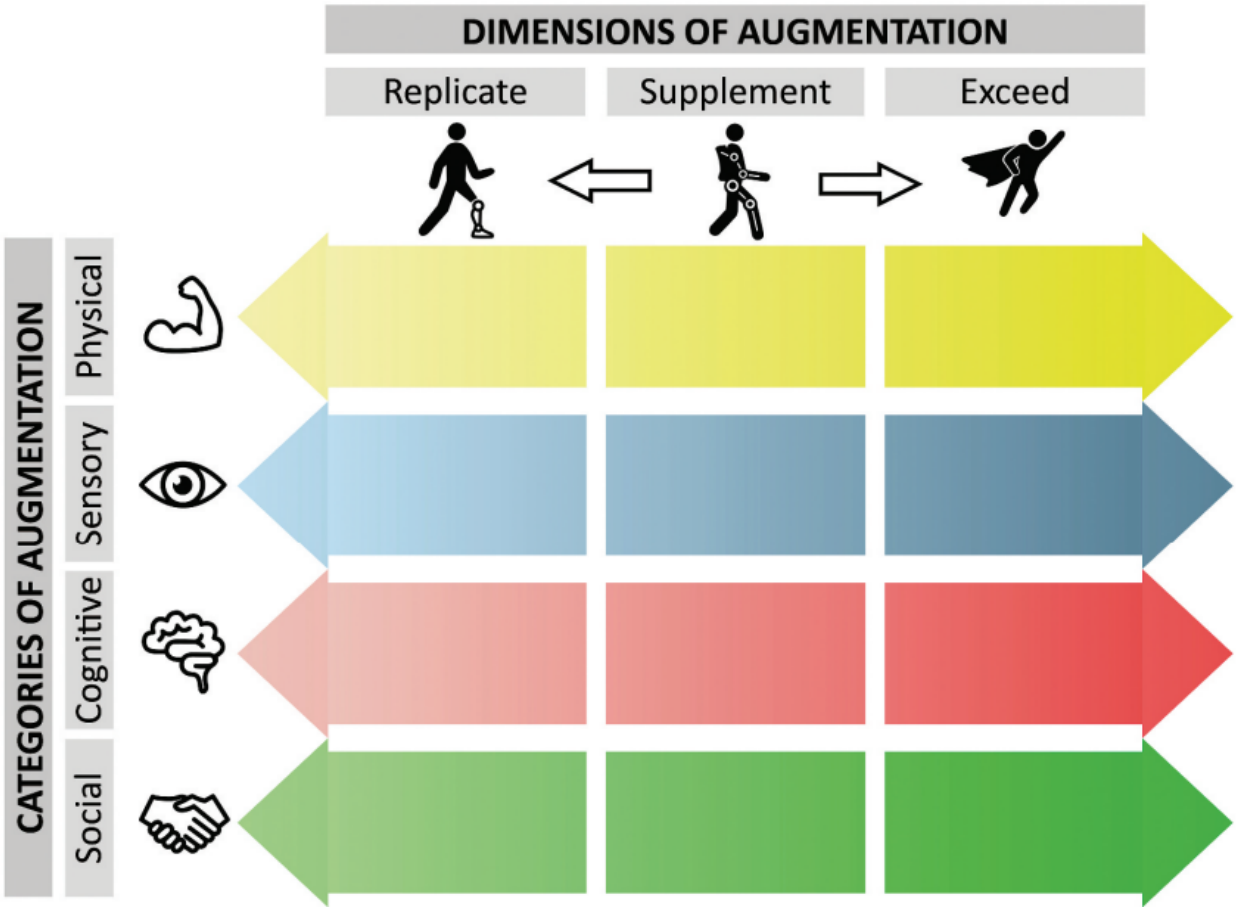
The field of Human Augmentation Technologies (HATs) focuses on enhancing human abilities related to sensing, action, and cognition, with a key emphasis on user control (Raisamo et al., 2019; Villa, Niess, Nakao et al., 2023). This paradigm is designed to improve human capabilities beyond their natural state, catering to all users seeking enhanced abilities (De Boeck & Vaes, 2021, 2024). HATs can replicate, restore, supplement, or exceed human capacities (De Boeck & Vaes, 2024; Pirmagomedov & Koucheryavy, 2021; Villa, Niess, Nakao et al., 2023) across physical, sensory, cognitive, and social categories (De Boeck & Vaes, 2024; Pedersen & Duin, 2021).

The boundaries of human augmentation can be challenging to define, as many technologies that act as extensions providing augmented information, such as wearables, fall within this category (Raisamo et al., 2019). However, HATs are distinct from assistive technologies focused on rehabilitation (Huber et al., 2018), as they are designed to improve human abilities as an extension or integration of the human body (De Boeck & Vaes, 2024). Furthermore, a product or technology qualifies as an augmentation only when it seamlessly integrates as an extension of an individual, becoming an intuitive part of their self (Alexander et al., 2016).

To provide a visual framework for this concept, see Figure 1, which highlights the various dimensions and categories of HATs.

πFigure 1

Visual framework of human augmentation possibilities (De Boeck & Vaes, 2024, p. 76)



To comprehensively describe human augmentation, De Boeck & Vaes (2024) suggested the following definition: "Human augmentation refers to the development of device-based technologies that aim to improve human abilities as an extension or integration of the human body by replicating, supplementing, or exceeding the physical, sensory, cognitive, and social capabilities of its user." (p. 76)

This definition aligns with the focus of this dissertation on bionic prostheses as an example of restorative physical HATs, making the term HATs, while it still can be thought of as a subcategory of EDTs, more precise and appropriate in this context. Moreover, it allows for the classification and investigation of specific technologies and applications regarding their psychological effects and social consequences in upcoming studies.

Consequently, this dissertation uses the term Human Augmentation Technologies instead of Embodied Digital Technologies.

2.2 Social Perception

Social perception, the process by which individuals form impressions and make inferences about others, is pivotal in shaping human interactions and societal dynamics. Humans, driven by the evolutionary importance of quickly identifying friends or foes, tend to form an instant impression of other human beings or agents when encountering them (Fiske et al., 2007). Humans leverage their social intellect to decode nonverbal cues and draw conclusions about others' intentions, emotions, motives, and traits. These processes seem to be rooted deeply within human nature, so even preverbal infants discriminate antisocial agents from prosocial ones and prefer interactions with the latter. (e.g., Buon et al., 2014; Fiske et al., 2007; Premack & Premack, 1997). This initial impression and categorization into benevolent and malevolent influences the decision to continue or discontinue interacting and how to behave (Fiske, 2018; McKee et al., 2022).

Understanding these cognitive processes provides insights into how individuals form judgments about others based on observable cues and behaviors (B. Meyer et al., 2016), which is crucial for deciphering the complexities of human social behavior (Fiske, 2018). Moreover, social perception contributes to identifying and examining stereotypes, which are cognitive

shortcuts that influence how people categorize and make assumptions about different social groups (Fiske et al., 2002).

In the context of emerging technologies and evolving societal structures, the relevance of social perception extends to novel areas, such as the evaluation of Human Augmentation Technologies. As technology becomes increasingly integrated into human lives, investigating how individuals perceive and interact with entities like bionic prostheses or other Human Augmentation Technologies becomes paramount. This research not only aids in understanding the psychological effects on users but also sheds light on the broader societal implications, including potential stigmatization or acceptance of augmented individuals.

2.2.1 Fundamental Dimensions of Social Perception

Perceiving and evaluating individuals is not a simple matter of categorizing them as either good or bad. Instead, it is a two-dimensional process considering task-related and social-emotional aspects. In evaluating themselves and others, people typically consider factors such as capacity and interpersonal or intergroup virtues. Throughout history, two fundamental functions of behavior and their interpretations have been recognized: accomplishing tasks and forming bonds. This concept of two primary dimensions in the perception of people can be traced back to ancient philosophy, as noted by Abele and Wojciszke (2014).

In addition to abstract knowledge, both verbal and nonverbal behavior play a crucial role in conveying information (B. Meyer et al., 2016). Nonverbal behavior includes facial expressions, body language, gestures, social touching, and interpersonal distance. For instance, demonstrations of competence and dominance, such as extensive poses (Cuddy et al., 2011), or of empathy and warmth, such as open gestures and smiling (Biancardi et al., 2017; Kraft-Todd et

al., 2017), have a significant impact on how observers perceive an individual and influence their impression formation.

Recent research on social judgment, including interpersonal and group perception and self-perception, has revealed empirical evidence that two fundamental content dimensions underlie these various judgments. Over time, researchers in many areas of psychology have systematically developed two-dimensional approaches to analyzing human perception and behavior, all of which ultimately boil down to the fundamental dimensions of social perception, namely Warmth/Communion and Competence/Agency (Abele et al., 2021; Abele & Wojciszke, 2014; Fiske, 2015).

The first dimension (Communion, Warmth) comprises positive traits like friendly, warm, honest, and good-natured, and negative traits like unreliable, cold, and deceitful. The second dimension (Agency, Competence) is characterized by positive traits such as intelligent, assertive, competent, and ambitious, and by negative traits such as passive, indecisive, inefficient, and lazy. (Abele et al., 2021; Fiske, 2015).

Despite being operationalized and assessed differently by researchers depending on the theoretical framework and research focus (e.g., Agency vs. Communion, Abele & Wojciszke, 2007; Warmth vs. Competence, Fiske et al. 2002; Morality vs. Competence, Wojciszke, 2005) at their core, those operationalizations coherently assess similar facets related to the two fundamental dimensions Warmth/Communion and Competence/Agency (Abele et al., 2021; Nicolas et al., 2022).

In sum, social perception is closely intertwined with fundamental dimensions that shape our understanding of others. Warmth/Communion and Competence/Agency are the foundation of social cognition, influencing how individuals, entities, and even organizations are perceived in

various contexts and cultural settings (e.g., Abele & Wojciszke, 2014; Cuddy et al., 2009; Fiske, 2015, Malone & Fiske 2013; McKee et al., 2023).

Since this dissertation focuses mainly on (self-)stereotyping, (self-) perception, and the assessment of HAT users, it uses the Stereotype Content Model and its operationalization (SCM, Fiske et al., 2002, 2018, Nicolas et al. 2022) as its primary theoretical foundation.

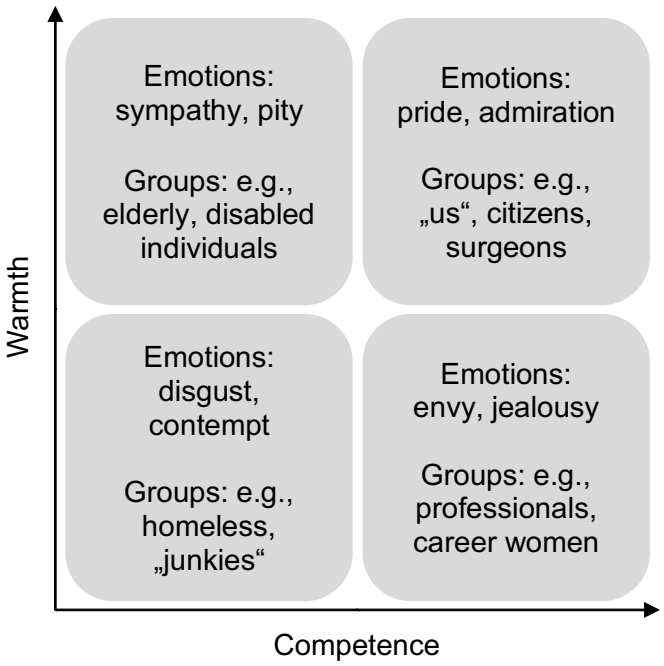
The SCM identifies Warmth and Competence as major dimensions, providing a framework for categorizing social groups and impacting the impressions people form (see Figure 2; Fiske et al., 2002; B. Meyer & Asbrock, 2018). The fundamental dimensions exhibit a noteworthy ambivalence, where positive evaluations on one dimension often coincide with negative evaluations on the other (e.g., a warm but incompetent disabled individual; a cold but competent career woman), evoking specific emotions, and giving rise to specific, subtle forms of devaluation (Fiske, 2015). Changes in one dimension's perception are frequently offset by opposite changes (Kervyn et al., 2009).

Cuddy and colleagues (2007) suggested that traits such as morality, trustworthiness, sincerity, kindness, and friendliness constitute the Warmth dimension, while Wojciszke (1994) discovered that behavior can be perceived based on either Competence or Morality.

Despite being fundamental, the SCMs two-dimensional approach has faced criticism, with research identifying a third distinct dimension - Morality. This led to the proposal of Morality as a separate factor, which was initially included within Warmth in the original model by Fiske (2018). The suggestion involved dividing Warmth into two distinct dimensions: Morality and Sociability, with Morality holding particular significance in the assessment of out-groups, as indicated by several studies (Heflick et al., 2011; Kervyn et al., 2015; Leach et al., 2007).

Figure 2

Illustration of the Stereotype Content Model (SCM) according to Fiske et al. (2002)



Sociability, on the other hand, refers to the ability of individuals to interact effectively, establish personal connections, and work efficiently as part of a group or team. In contrast, Morality involves distinguishing between right and wrong and acting according to one's values at its core (Kervyn et al., 2015).

The interplay of nonverbal behavior, Warmth, and Competence cues further enriches the complexity of social intellect, revealing the subtle yet influential factors that contribute to our social perceptions (Ambady & Weisbuch, 2010; Cook et al., 2019; B. Meyer et al., 2016). While the Primacy-of-Warmth effect is evident in social judgments (Asch, 1946; Fiske et al., 2007; Wojciszke, 2005), workplace perceptions emphasize the fundamental role of Competence, underscoring the intricate dynamics at play in social perception (Abele & Wojciszke, 2014). This exploration into fundamental dimensions lays the foundation for a deeper comprehension of the

complexities of social perception, offering valuable insights for future research in the field of HATs.

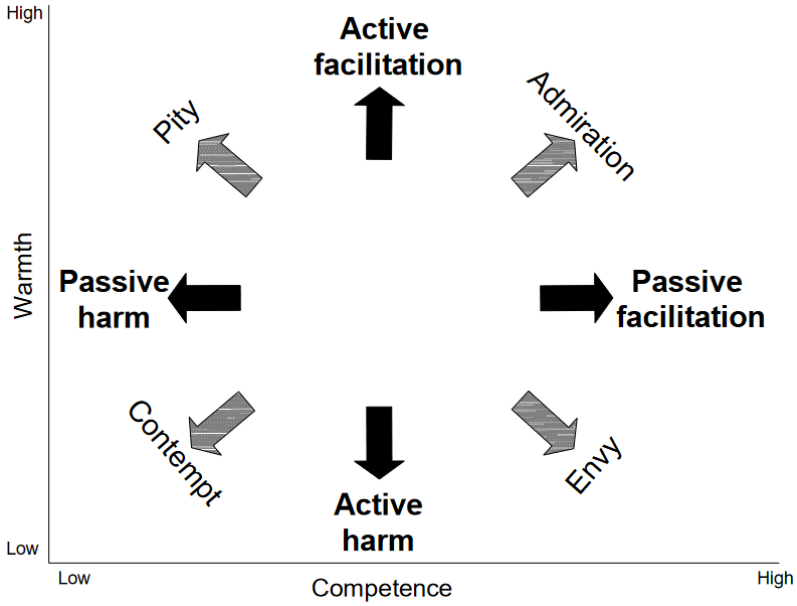
2.2.2 Emotional and Behavioral Consequences

The SCM (Fiske et al., 2002) and the BIAS-Map (Cuddy et al., 2007) provide insights into stereotypes' emotional and behavioral consequences. The SCM identifies distinct emotional prejudices associated with different combinations of stereotypes, such as admiration, contempt, envy, and pity (Fiske et al., 2002; Cuddy et al., 2007; Cuddy et al., 2009).

Beyond that, the BIAS-Map extends the SCM by linking these emotions to specific behavioral tendencies, going beyond just understanding the structural aspects of stereotypes to predict behavioral responses (Cuddy et al., 2007). Warmth stereotypes shape active behavioral tendencies by diminishing active harm, such as harassment, and fostering active facilitation, like helping. In contrast, Competence stereotypes influence passive behavioral tendencies, mitigating passive harm, such as neglect, and promoting passive facilitation, such as association. Admired groups, characterized by Warmth and Competence, evoke both facilitation and are devoid of harm tendencies, while hated groups, marked by coldness and incompetence, provoke harm and lack facilitation tendencies. Envied groups, perceived as competent and cold, elicit passive facilitation alongside active harm, whereas pitied groups, seen as warm and incompetent, prompt active facilitation coupled with passive harm (see Figure 3). Emotions play a more potent role in predicting behavioral tendencies than stereotypes, frequently mediating the link between stereotypes and behavioral inclinations (Cuddy et al., 2007, 2008; Cuddy et al., 2009).

Figure 3

Schematic representation of BIAS Map (Cuddy et al., 2007, p. 634)



Note. "Emotions are represented by gray arrows, within the figure on diagonal axes. Behavioral tendencies are represented by black arrows, within the figure on horizontal and vertical axes" (Cuddy et al., 2007, p. 634).

Both models emphasize the importance of Warmth and Competence dimensions in shaping perceptions and subsequent emotional and behavioral reactions to stereotyped groups in various contexts (Boysen et al., 2023; Cuddy et al., 2007; Fiske et al., 2002; Froehlich & Schulte, 2019; Mieczkowski et al., 2019). Understanding these emotional and behavioral consequences is crucial for comprehending how stereotypes impact individuals and groups, influencing interactions and societal dynamics.

2.2.3 Social Perception in HAT Evaluation

Despite the enduring interest in the fundamental dimensions of social perception (for an integrative summary, see Abele et al., 2021), research on the impact of bionic technology on self

and other perceptions has mainly been confined to analyzing the uncanny valley phenomenon (Mori et al., 2012). This phenomenon posits that nearly human-like EDTs, falling short of complete realism, trigger negative emotions such as unease. Recent studies propose that this reaction stems from a mismatch between human and artificial cues (Kätsyri et al., 2015).

Previous research indicates that restorative motor HATs (i.e., bionic prostheses) affect the perception of people with disabilities. By applying the SCM, people with physical disabilities are commonly perceived as warm but incompetent (Asbrock, 2010; Barg et al., 2010; B. Meyer & Asbrock, 2018). However, using bionic prostheses influences this evaluation of Warmth and Competence, restoring Competence while maintaining Warmth compared to those without bionic prostheses (B. Meyer & Asbrock, 2018). Cyborgs,[2] however, are seen as less warm but more competent than their human counterparts (B. Meyer & Asbrock, 2018). Beyond that, an SCM and, by extension, BIAS-Map perspective offers a nuanced understanding of the uncanny valley phenomenon: The possible improvement of human abilities and the associated increase in perceived Competence can evoke specific positive (admiration) and negative (envy) emotions (Fiske et al., 2002). The emotional response tied to Competence depends on the Warmth dimension, with Warmth also predicting negative emotions like anger and fear (Cuddy et al., 2008). This suggests that HATs not fully resembling a human may elicit negative emotions when perceived as competent and cold (envy, fear, anger), while being perceived as competent and warm may evoke positive emotions (admiration, liking).

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[2] Defined by B. Meyer & Asbrock (2018) as a "human being with both organic and biomechatronic body parts" (p. 5).

As previously stated, individuals use verbal and nonverbal actions, abstract knowledge, and categorical cues to gather information about others (B. Meyer et al., 2016). For instance, individuals exhibit complementary behaviors in response to displays of dominance or submission and shift their gaze away from partners' nonverbal dominance cues (Holland et al., 2017; Tiedens & Fragale, 2003). Therefore, people can decipher nonverbal behavior in individuals using HATs, particularly their body language, which may differ from those without or non-bionic prostheses.

Nevertheless, the realm of bionic technology and its impact on self and other perceptions remains relatively unexplored, with a scarcity of research shedding light on this intricate interplay. The limited body of work in this domain reflects a broader gap in our understanding of how bionic enhancements shape individuals' perceptions of themselves and others. Moreover, investigating the predictors influencing Warmth and Competence perceptions in the context of bionic HATs is notably sparse. This scarcity of research hampers a comprehensive grasp of the factors contributing to the social perceptions surrounding these advanced technologies. The challenges inherent in researching this field are further exacerbated by the limited accessibility of bionic technologies and their existence in early prototype stages. The nascent nature of these technologies poses methodological hurdles, making it challenging to conduct extensive empirical studies. Consequently, the constrained research landscape not only underscores the need for more in-depth inquiries into the psychological ramifications of bionic technology but also emphasizes the hurdles researchers face in navigating the complexities of this emerging field.

2.3 Self-perception

A crucial area warranting more in-depth exploration involves discerning the distinctions between self-perceptions and perceptions of others concerning HATs. No studies have explored

the impact of wearing a bionic prosthesis on essential self-evaluations like Competence and Sociability, and there is a notable absence of research on how bionic prostheses influence users' self-image and self-attributions. While one study (Saradjian et al., 2008) has examined the psychological consequences of the traumatic loss of an arm and subsequent prosthesis fitting, it focused on individuals without bionic prostheses while emphasizing perceived functional and cosmetic benefits.

Individuals tend to assess Warmth and Competence, or Communion and Agency, differently when considering themselves versus others. The Dual Perspective Model (Abele & Wojciszke, 2014) posits the Primacy-of-Warmth effect, asserting that the Warmth dimension holds greater significance in the perception of others. This implies that Warmth-related information is processed more swiftly and garners heightened interest from observers (Abele & Bruckmüller, 2011). Furthermore, individuals are more perturbed by the discrediting of their Warmth than their Competence (Abele & Hauke, 2019). However, it is noteworthy that self-esteem exhibits a stronger correlation with Competence. Research indicates that individuals tend to describe themselves more in terms of Competence and Agency while attributing Warmth and Communion more to others (Wojciszke & Abele, 2008). The DPM focuses on self-perception and the perception of close others. The SCM, however, is applicable to the perception of outgroups. As mentioned above, the dimensions of Warmth and Competence (SCM) and Communion and Agency (DPM) are essentially the same (Abele et al., 2021). Consequently, in theory, the operationalization of the SCM could also be applied to self-perception. Concerning improving / augmenting HATs (i.e., exoskeletons), Gilotta et al. (2018) also mentioned social aspects that might reduce acceptability. Exoskeletons, when worn, may cause workers in the workplace to be stigmatized as they may seem reliant on the support provided by the exoskeletons. Comparably,

users of restorative HATs (i.e., bionic prostheses) may perceive themselves as inferior due to their dependency on the device, affecting central self-evaluations.

2.4 Research objectives

In a nutshell, recent research based on the SCM shows that the usage of HATs and their degree of technicity influences the perception of their users on the Warmth and Competence dimensions. Given that, investigating the impact of HATs on self- and other-perception is a pressing research problem. Despite ongoing research, there is still a lack of understanding regarding the users' perspective.

Consequently, two major research goals can be derived. First, this dissertation aims to extend the still limited scientific knowledge regarding the social perception of HAT users by replicating and refining prior studies. Second, the explicit experiences of HAT users are assessed to broaden and enrich prior research findings by including a crucial but under-researched perspective. Concerning these research goals, this dissertation seeks to answer two specific research questions:

(1) How are users of (restorative motor) HATs perceived in terms of the three dimensions: Competence, Sociability, and Morality?

(2) How does using (restorative motor) HATs affect user's self-perception, meta-perception, and everyday experiences in social interactions?

3 Study summaries

A mixed-methods approach was employed, and three studies were conducted. This approach was designed to meet the research objectives and contribute to the existing research by answering the derived research questions.

Based on prior research by B. Meyer and Asbrock (2018), the first study, while addressing research question one, seeks to investigate further, replicate, and extend findings on the social perception of individuals with prostheses varying in technicality while using adapted stimuli. Likewise, this study aims to expand the understanding of these dimensions by differentiating Warmth into Morality and Sociability (Kervyn et al., 2015; Leach et al., 2007).

Since the previous studies have yielded conflicting outcomes regarding the perceived Competence of users with low- and high-tech prostheses, study two seeks to replicate and build upon these findings, further exploring the nuanced social perceptions of individuals with prostheses characterized by different technological levels. Thus, the focus was again on research question one by examining how others perceive users of various prostheses in terms of Competence, Sociability, and Morality.

At this point, research on such technologies' effect on their users' self-perception still needs to be included. The third study aims to fill this gap with an explorative qualitative approach. Study three specifically addresses research question two by examining users self-perception and supplements the prior findings regarding research question one when investigating HAT users meta-perception. Semi-structured interviews with expert users of bionic arm prostheses' regarding self-perception and how they believe others see them (meta-perception) derived a deeper understanding.

As mentioned above, the fundamental dimensions of Warmth/Communion and Competence/Agency can be considered the same. Given this and the focus of study 3, namely not only self- but meta-perceptions, and due to consistency within the dissertation project, the theoretical focus of the study lies within the SCM.

These studies are published as mentioned below and will be summarized and discussed in the upcoming sections of this dissertation:

Study 1: Mandl, S., **Bretschneider, M.**, Meyer, S., Gesmann-Nuissl, D., Asbrock, F., Meyer, B., & Strobel, A. (2022). Embodied Digital Technologies: First insights in the social and legal perception of robots and users of prostheses. *Frontiers in Robotics and AI, 9*, Article 787970. https://doi.org/10.3389/frobt.2022.787970

Study 2: **Bretschneider, M.**, Mandl, S., Strobel, A., Asbrock, F., & Meyer, B. (2022). Social perception of embodied digital technologies – a closer look at bionics and social robotics. *Gruppe. Interaktion. Organisation. Zeitschrift für Angewandte Organisationspsychologie (GIO), 53*, 343-358. https://doi.org/10.1007/s11612-022-00644-7

Study 3: **Bretschneider, M.**, Meyer, B., & Asbrock, F. (2023). The impact of bionic prostheses on users' self-perceptions: A qualitative study. *Acta Psychologica*, *241*, Article 104085. https://doi.org/10.1016/j.actpsy.2023.104085

While the first two studies investigated both robots and HATs[3], HAT-related results will be prioritized to align with the research goals regarding the impact of HATs on social perception. This targeted focus ensures a nuanced exploration of the specific domain under investigation, allowing for a more comprehensive and in-depth analysis of the psychological implications

[3] Please note that due to the broader perspective of the studies, the term EDTs is used in the papers.

associated with HAT usage. The focus of paper 3 was solely on HATs, or more precisely, on bionic forearm prostheses.

3.1 Study 1: Embodied Digital Technologies: First insights in the social and legal perception of robots and users of prostheses

The increasing prevalence of HATs, such as bionic prostheses, prompts a critical examination of how these technologies are perceived. The Stereotype Content Model establishes Warmth and Competence as two pivotal dimensions of social perception (Fiske, 2018; Fiske et al., 2002). Previous research identified warm and incompetent stereotypes for individuals with physical disabilities (Asbrock, 2010), and users of bionic prostheses were perceived as more competent while maintaining Warmth attribution (B. Meyer & Asbrock, 2018).

Building upon prior research by B. Meyer and Asbrock (2018), the investigation seeks to replicate and extend findings on the social perception of individuals with prostheses varying in technicality. Furthermore, this study aims to expand the understanding of these dimensions by differentiating Warmth into Morality and Sociability (Kervyn et al., 2015; Leach et al., 2007).

The study was preregistered on OSF (https://osf.io/xevkp) and approved by the local Ethics Committee. With a substantial sample size of $N = 459$, the study utilized 11 pictures depicting individuals with and without low- and high-tech prostheses, along with different robots, accounting for various disabilities and prostheses (please see the OSF folder, https://osf.io/xsn5a). It was conducted as an online experiment.

Mixed Models were employed to address correlated errors, nested data, and related effects, ensuring accurate estimates for the statistical analyses conducted in the study. The data analysis revealed that Restored Functionality (RF), representing the regaining of abilities

comparable to non-disabled individuals, played a more significant role in shaping attributions than the Grade of Technicity (GoT).

The Mixed Model analysis revealed a significant positive association between Restored Functionality (RF) and perceived Competence (Table 1). Post-hoc Tukey tests demonstrated that users of low-tech prostheses were perceived as significantly less competent than both users of high-tech prostheses (ΔM = -0.30, SE = 0.04, t = -7.59, p < .001) and non-disabled individuals (ΔM = 0.31, SE = 0.04, t = 8.01, p < .001). However, no significant difference in perceived Competence was observed between users of high-tech prostheses and non-disabled individuals (ΔM = 0.02, SE = 0.04, t = 0.42, p = 0.998).

Table 1

Comparison of Fit Indices for Linear Mixed Models regressing Competence on Restored Functionality for human stimuli

Predictors	Model 0			Model 1			Model 2			Model 3		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
(Intercept)	3.83	0.02	<.001**	3.43	0.03	<.001**	3.43	0.03	<.001**	4.15	0.13	<.001**
RF				0.16	0.01	<.001**	0.16	0.01	<.001**	0.16	0.01	<.001**
Gender										-0.24	0.04	<.001**
Education										-0.05	0.02	.003**
Age										-0.00	0.00	.207
Random Effects												
σ^2	0.15			0.13			0.10			0.10		
τ_{00}	0.14 $_{id}$			0.15 $_{id}$			0.26 $_{id}$			0.24 $_{id}$		
τ_{11}							0.03 $_{id.rf}$			0.03 $_{id.rf}$		
ρ_{01}							-0.62 $_{id}$			-0.62 $_{id}$		
ICC	.49			.55			.65			.63		
Model fit												
Marginal R^2	0.000			0.055			0.055			0.112		
Condi-tional R^2	0.490			0.572			0.671			0.673		

	Model 0	Model 1	Model 2	Model 3
AIC	1927.5	1774.1	1752.0	1737.6
BIC	1943.2	1795.0	1783.4	1784.7
χ^2		155.39**	26.09**	20.39**

Note. N = 459, Observations = 1377; RF = Restored Functionality.

* $p < .05$. ** $p < .01$.

In contrast, there was no significant association between RF and perceived Sociability. Regarding perceived Morality, a negative association with RF was observed (Table 2). Post-hoc Tukey tests indicated that perceived Morality was higher for people with disabilities, regardless of prosthetic technicity (non-disabled individuals vs. users of low-tech prostheses: $\Delta M = 0.16$, $SE = 0.02$, $t = 9.14$, $p < .001$; non-disabled individuals vs. users of high-tech prostheses: $\Delta M = 0.12$, $SE = 0.02$, $t = 6.77$, $p < .001$). The difference in perceived Morality between users of high- and low-tech prostheses showed a trend toward significance on a descriptive level ($\Delta M = 0.04$, $SE = 0.02$, $t = 2.37$, $p = .050$).

Table 2

Comparison of Fit Indices for Linear Mixed Models regressing Morality on Restored Functionality for human stimuli

Predictors	Model 0			Model 1			Model 2			Model 3		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
(Intercept)	3.56	0.02	<.001**	3.72	0.03	<.001**	3.72	0.03	<.001	4.25	0.12	<.001**
RF				-0.08	0.01	<.001**	-0.08	0.01	<.001	-0.08	0.01	<.001**
Gender										-0.13	0.04	<.001**
Education										-0.04	0.02	.028*
Age										-0.00	0.00	.015*
Random Effects												
σ^2	0.08			0.07			0.05			0.07		

	Model 0	Model 1	Model 2	Model 3
τ_{00}	0.13 $_{id}$	0.14 $_{id}$	0.18 $_{id}$	0.13 $_{id}$
τ_{11}			0.02 $_{id.rf}$	
ρ_{01}			-0.49 $_{id}$	
ICC	.64	.66	.74	.65
Model fit				
Marginal R^2	0.000	0.020	0.020	0.054
Conditional R^2	0.639	0.669	0.741	0.670
AIC	1199.8	1129.8	1109.9	1115.6
BIC	1215.5	1150.7	1141.3	1162.7
χ^2		155.39**	26.09**	20.39**

Note. $N = 459$, Observations = 1377; RF = Restored Functionality.

*$p < .05$. **$p < .01$.

To summarize the results, individuals with bionic prostheses were viewed as more competent than those with low-tech prostheses, and concurrently, they were attributed higher Morality than non-disabled individuals. This suggests that their disability continued to influence social perception, consistent with prior findings (B. Meyer & Asbrock, 2018). Interestingly, the perception of Sociability did not correlate with the types of prostheses.

3.2 Study 2: Social perception of embodied digital technologies – a closer look at bionics and social robotics

The objective of this study aligned with Paper 1 (Mandl, Bretschneider, Meyer et al., 2022), focusing on an in-depth examination of social perception in the context of the growing presence of HATs, particularly in private and work environments. Acknowledging critical concerns regarding the adoption of new technologies, especially in workspaces, where issues like job displacement and reduced human interaction have been identified (Chao & Kozlowski, 1986; Gilotta et al., 2019; Savela et al., 2021), understanding user perceptions becomes crucial. This is

particularly relevant in implementing industrial robots or HATs like bionic prostheses or exoskeletons. The study leveraged the Stereotype Content Model (Fiske et al., 2002) to explore the dimensions of Competence and Warmth in social perception. Responding to criticism, we further delved into the subdimensions of Morality and Sociability (Kervyn et al., 2015; Leach et al., 2007; Mandl, Bretschneider, Meyer et al., 2022).

The impact of prostheses with varying degrees of technicity remains uncertain, as previous studies have yielded conflicting outcomes regarding the perceived Competence of users with low- and high-tech prostheses. This study seeks to replicate and build upon these findings, further exploring the nuanced social perceptions of individuals with prostheses characterized by different grades of technicity. Thus, the focus was on examining how users of various prostheses and different types of robots are perceived in terms of Sociability, Morality, and Competence.

Prior to data collection, it was preregistered on OSF (https://osf.io/6st2b), ensuring transparency and accountability in the research process. The procedure underwent thorough evaluation and received approval from the local Ethics Committee. The study involved a sample size of $N = 338$. The stimulus material used was identical to that in Study 1 and is available on OSF (https://osf.io/qz2ca/). In alignment with the aim of replication, the procedure mirrored that of Study 1. Mixed Models were utilized to handle correlated errors, nested data, and their associated effects, ensuring precise estimates for the statistical analyses conducted in the study.

The data analysis indicated that Restored Functionality (RF), signifying the regaining of abilities comparable to non-disabled individuals, was a more explanatory factor than the Grade of Technicity (GoT) in shaping attributions. Thus, a Mixed Model regressing Competence on RF was conducted. The model with a random intercept yielded the best fit, demonstrating a positive association between RF and Competence attributions (Table 3). Posthoc Tukey tests

indicated that users of low-tech prostheses were not perceived as less competent than users of bionic prostheses ($M = 0.07$, $SE = 0.03$, $p = .085$, $d = 0.16$) but as less competent than non-disabled individuals ($M = 0.14$, $SE = 0.03$, $p < .001$, $d = 0.34$). No significant differences in perceived Competence were found between users of bionic prostheses and non-disabled individuals ($M = 0.08$, $SE = 0.03$, $p = .055$, $d = 0.18$).

Table 3

Comparison of Fit Indices for Linear Mixed Models regressing Competence on Restored Functionality for human stimuli

Predictors	Model 0			Model 1			Model 2		
	b	*SE*	*CI*	*b*	*SE*	*CI*	*b*	*SE*	*CI*
(Intercept)	3.88	0.03	[3.82, 3.94]	3.74	0.05	[3.65, 3.82]	4.25	0.21	[3.82, 4.67]
RF				0.07	0.02	[0.04, 0.10]	0.07	0.02	[0.04, 0.10]
Gender							-0.16	0.06	[-0.28, -0.04]
Age							-0.01	0.00	[-0.01, -0.00]
Education							-0.01	0.03	[-0.07, 0.05]
Random Effetcs									
σ^2	0.18			0.18			0.18		
τ_{00}	0.27_{id}			0.27_{id}			0.26_{id}		
τ_{11}									
ρ_{01}									
ICC	.60			.61			.60		
Model Fit									
Marginal R^2	0.000			0.008			0.034		

	Model 0	Model 1	Model 2
Conditional R^2	0.599	0.610	0.612
AIC	1737.5	1726.5	1738.9
BIC	1752.3	1746.2	1773.4
$\chi 2$		13.07**	0.00

For evaluating differences in perceived Sociability, a Mixed Model regressing Sociability on RF showed no significant association. Assessing differences in perceived Morality, a Mixed Model regressing Morality on RF revealed a negative association (Table 4). Post-hoc Tukey tests showed that users of low-tech prostheses were attributed significantly more Morality than users of high-tech prostheses ($M = 0.12$, $SE = 0.02$, $p < .001$, $d = 0.47$), and non-disabled individuals ($M = 0.16$, $SE = 0.02$, $p < .001$, $d = 0.65$). Morality attributed to high-tech prosthesis users and non-disabled individuals was found to be similar, with no significant differences. However, a slight tendency was observed in the results. ($M = 0.05$, $SE = 0.02$, $p = .050$, $d = 0.18$).

The results revealed nuanced perceptions of individuals with different types of prostheses. Users of bionic prostheses were perceived as equally competent as those with low-tech prostheses, supported by a minimal effect size. Interestingly, people with low-tech prostheses were perceived as less competent than non-disabled individuals, a contrast not observed for users of bionic prostheses. These findings partly align with previous research, where users of bionic prostheses were perceived as more competent than individuals with physical disabilities in general (B. Meyer & Asbrock, 2018) and users of low-tech prostheses (Mandl, Bretschneider, Meyer et al., 2022) but less (B. Meyer & Asbrock, 2018) or equally as competent as non-disabled individuals (Mandl, Bretschneider, Meyer et al., 2022).

Table 4

Comparison of Fit Indices for Linear Mixed Models regressing Morality on Restored Functionality for human stimuli

Predictors	Model 0			Model 1			Model 2			Model 3		
	b	*SE*	*CI*	*b*	*SE*	*CI*	*b*	*SE*	*CI*	*b*	*SE*	*CI*
Intercept	3.60	0.02	[3.55, 3.64]	3.76	0.03	[3.70, 3.82]	3.76	0.03	[3.70, 3.82]	4.13	0.16	[3.81, 4.44]
RF				-0.08	0.01	[-0.10, -0.06]	-0.08	0.01	[-0.10, -0.06]	-0.08	0.01	[-0.10, -0.06]
Gender										-0.06	0.04	[-0.15, 0.03]
Age										0.00	0.00	[-0.01, 0.00]
Education										-0.04	0.02	[-0.08, 0.01]
Random Effects												
σ^2	0.07			0.06			0.05			0.06		
τ_{00}	0.16 $_{id}$			0.16 $_{id}$			0.19 $_{id}$			0.16 $_{id}$		
τ_{11}							0.01 $_{id\ rf}$					
ρ_{01}							-0.38 $_{id}$					
ICC	.69			.71			.77			.71		
Model Fit												
Marginal *R*2	0.000			0.020			0.020			0.032		
Conditional *R*2	0.690			0.719			0.772			0.721		

Predictors	Model 0	Model 1	Model 2	Model 3
AIC	900.38	842.44	832.00	863.45
BIC	915.14	862.00	861.53	897.90
$\chi 2$		59.94**	14.44**	0.00

Note. N = 338, Observations = 1014; RF = Restored Functionality. CI = 95% confidence interval. Bootstrap confidence intervals were constructed using 10 000 resamples.

This suggests that regardless of technicity, prostheses contribute to perceived Competence. Users of low-tech prostheses seem to occupy an intermediate space, perceived as competent as bionic prostheses but less competent than non-disabled individuals, highlighting the nuanced nature of social perceptions.

Consistent with prior research, individuals with disabilities, irrespective of prosthesis type, were perceived as sociable as non-disabled individuals (Mandl, Bretschneider, Meyer et al., 2022). Differences emerged in perceived Morality, with people with low-tech prostheses differing from users of bionic prostheses and non-disabled individuals. This aligns with prior findings, indicating higher attributions of Morality to individuals with low-tech prostheses compared to non-disabled individuals, while no significant difference was found between users of bionic prostheses and non-disabled individuals (Mandl, Bretschneider, Meyer et al., 2022).

3.3 Study 3: The impact of bionic prostheses on users' self-perceptions: A qualitative study

Given the limited research on the psychological effects of utilizing bionic prostheses, a qualitative study was conducted involving highly proficient users of such prostheses. The primary objective was to unearth fundamental psychological concepts influenced by the use of bionic prostheses and to delve into the potential psychological processes that underlie these effects. Previous research predominantly focused on the functional utility and cosmetic aspects, emphasizing the prostheses' ability to appear 'normal' (Saradjian et al., 2008). However, we recognized the need to explore whether bionic prostheses could affect self-worth in ways extending beyond the mimicry of natural body parts. Additionally, the study sought to evaluate the applicability of the Stereotype Content Model (SCM; Fiske et al., 2007) as a theoretical framework for elucidating the effects of bionic prostheses on self- and other perceptions. In essence, our research addressed how wearing a bionic prosthesis shapes self- and other

perceptions from the users' perspective. Given the diverse outcomes in prior research (Bretschneider et al., 2022; Mandl, Bretschneider, Meyer et al., 2022; B. Meyer & Asbrock, 2018), the aim was to expand on current research regarding the psychological effects of utilizing bionic prosthetics. We accomplished this by conducting an exploratory qualitative study that investigates how users perceive themselves, how they believe others perceive them, and how they experience social interactions on a daily basis. Through this approach, we aimed to contribute to developing a theoretical understanding of how the use of bionic prostheses influences self-perceptions and attributions. Additionally, our study shed light on whether the SCM is a suitable framework for comprehending the effects of using a bionic prosthesis on its users.

Specifically, the interest lies in understanding how self- and meta-perceptions change when individuals transition from a low-tech or no prosthesis to a bionic one. The methodology combined thematic analysis (Braun & Clarke, 2006) with elements of qualitative content analysis (Mayring, 2015). The sample, comprising $N = 10$ participants, all with a bionic forearm prosthesis, was initially gathered through convenience sampling and subsequently expanded through snowballing. Semi-structured interviews were conducted using a pre-prepared guideline derived from theoretical considerations based on the Stereotype Content Model (SCM; Fiske et al., 2002) and recent studies on the social perception of bionic prostheses (Bretschneider et al., 2022; Mandl, Bretschneider, Meyer et al., 2022; B. Meyer & Asbrock, 2018). The interviews aimed to explore users' self-perceptions and meta-perceptions regarding the prostheses, focusing on the SCM's fundamental dimensions of Warmth and Competence. Additionally, the investigation delved into whether different types of prostheses lead to varied attributions, considering insights from prior research (B. Meyer & Asbrock, 2018). Given the workplace

context, where Competence is perceived as more fundamental than Warmth (Abele & Wojciszke, 2014), interview questions were tailored accordingly. The study protocol receives review and approval from the local Ethics Committee.

To summarize, these findings suggest that the use of a bionic prosthesis has a significant impact on how users view themselves and how they perceive the actions of others towards them. All interview participants had previous experiences without a bionic prosthesis, encountering stigmatizing reactions aligned with the Stereotype Content Model (SCM) for individuals with physical disabilities (Fiske et al., 2007), such as pity and disgust. Transitioning to the bionic device correlated with perceiving positively connoted interest from others, leading to increased self-efficacy and, at times, pride. These results suggest a noticeable psychological impact, countering the stigma linked with disability in both external behaviors and self-perceptions. The experiences indicate that a bionic prosthesis can mitigate stereotyping behaviors, reducing self-stigmatization and self-stereotyping. Notably, changes in other perceptions persist even with repeated contact, including interactions with close peers like work colleagues, suggesting the stability of self-evaluative changes induced by wearing a bionic prosthesis. Overall, the findings highlight a dual identity among interviewees, influenced by situational properties, with bionic prostheses contributing to integration in the work context, partially due to heightened ascribed Competence (Vornholt et al., 2013).

Briefly, using bionic prostheses significantly influences social perception, stereotypes, and interpersonal perspectives, making users perceive more positive evaluations from others.

4 Discussion

The presented studies aimed to investigate the psychological effects of HAT usage, focusing on bionic prostheses. It sought to understand how these technologies influence users'

self-perception and how others perceive them, employing a mixed-methods approach to explore social dimensions and potential consequences.

As Study 1 and Study 2 pursued the same research objectives, the results are discussed concisely. In examining the perception of Competence among users of low- and high-tech prostheses and non-disabled individuals, Study 1 revealed that users of bionic prostheses were perceived as more competent than users of low-tech prostheses. Meanwhile, Study 2 found no significant difference between users of high- and low-tech prostheses, but users of low-tech prostheses were perceived as less competent than non-disabled individuals. Intriguingly, this trend did not hold for users of bionic prostheses, who were perceived as equally competent as their able-bodied counterparts.

These mixed results present a nuanced perspective, only partly aligning with previous research where users of bionic prostheses were perceived as more competent than individuals with physical disabilities but less competent than those without disabilities (B. Meyer & Asbrock, 2018). Users of low-tech prostheses appeared to occupy a middle ground, perceived as competent as users of bionic prostheses but less competent than non-disabled individuals. The findings suggest that regardless of technicity, prostheses contribute to perceived Competence. Notably, in one study, users of bionic prostheses were perceived as competent as individuals without physical disabilities, hinting at a potential influence of prosthesis technicity on perceived Competence, albeit marginally. It remains to be explored in future research whether these differences in perceived Competence persist over time.

In examining the perception of Morality across both studies, distinct patterns emerged. In Study 1, prosthesis users, irrespective of the technicity, were attributed higher levels of Morality than non-disabled individuals. This alignment with prior research (B. Meyer & Asbrock, 2018)

suggests that the presence of a prosthesis did not fully mitigate the impact of their disability on social perception. In Study 2, differences were observed between individuals with low-tech prostheses and both users of bionic prostheses and non-disabled individuals concerning perceived Morality. However, no significant distinctions were found between non-disabled individuals and users of high-tech prostheses. These nuanced findings underscore the complexity of moral attributions and how they relate to the type of prosthesis used.

In both studies examining the perception of Sociability, no significant associations were found with the types of prostheses. This observation supports the rationale behind dividing Warmth's Stereotype Content Model dimension into Morality and Sociability (Heflick et al., 2011; Kervyn et al., 2015; Leach et al., 2007). Our interpretation suggests that this lack of association may be attributed to the prevailing stereotype of individuals with physical disabilities, encompassing attributes such as tolerance and sincerity (Fiske et al., 2002), which align more closely with Morality than Sociability within the Warmth dimension.

Both studies examined restorative motor HATs through the lens of the Stereotype Content Model (SCM; Fiske et al., 2002) and the BIAS Map (Cuddy et al., 2008). These frameworks suggest that individuals evaluate others based on Warmth (indicating good to bad intentions) and Competence (ranging from incompetent to competent). People with physical disabilities are often perceived as warm but incompetent (Asbrock, 2010; B. Meyer & Asbrock, 2018). As hybrids and non-hybrids share the same category of humanness (S. Meyer et al., 2023), the SCM and BIAS Map are applicable. They propose ambivalent relationships between Warmth and Competence, where increased Competence attributions coincide with decreased warmth attributions. Overall, the results indicate that HATs influence users' social perception, and the SCM/BIAS Map perspective serves as a valuable framework for studying these effects

(also supported by findings on the applicability of this perspective to perceptions of generative (AI; McKee et al., 2023).

The third study supplemented the prior experimental studies with a novel perspective while, to the author's knowledge, for the first time addressing HAT users' self- and meta-perspective. By doing so, specific insights and a deeper understanding of the psychological effects of HAT use are provided. Study 3 focused on users' experiences with HATs, specifically on individuals utilizing bionic forearm prostheses. Semi-structured interviews were conducted with bionic prosthesis users to examine their self- and meta-perceptions. Additionally, the applicability of the SCM (Fiske et al., 2002) and BIAS Map (Cuddy et al., 2007) to the self-perceptions of HAT users was assessed.

In accordance with the DPM predictions, users described themselves in order of Competence/Agency. They felt more competent and experienced more self-efficacy while wearing their prosthesis. Aligned with the SCM/BIAS Map perspective, users linked wearing their prosthesis to increased feelings of Competence, reduced pity from others, positive social interactions, and visibility in public. Despite instances of misunderstanding or hostility, all participants reported significant effects on how others perceive and behave toward them. The findings underscored the profound impact of bionic prosthesis usage on users' self-perception and their interpretations of others' behaviors towards them. Notably, the study revealed that a bionic prosthesis could counteract stereotypical behaviors, mitigating self-stigmatization and self-stereotyping among users. These insights align with previous research (B. Meyer & Asbrock, 2018), emphasizing the potential of bionic prostheses in reducing disability-related stigmatization.

However, the interview results unveiled a nuanced and intricate panorama. While the bionic prosthesis could alleviate certain stigmatizing behaviors, it did not completely replace the stigmatized identity of individuals with disabilities. Instead, it introduced a simultaneous dual identity: a competent and warm cyborg. Managing this dual identity proved challenging as different aspects became salient in varying contexts (Gonzalez & Brown, 2006). Therefore, the positive psychological benefits of the bionic prosthesis necessitated users to navigate between the competent identity conferred by the device and the persisting stigma associated with their disability, mainly when the prosthesis was not worn or visible.

Putting on the bionic prosthesis was identified as a transformative act that highlighted a different identity. Building on Studies 1 and 2 and the theoretical framework, these results may extend to the effects of other embodied bionic technologies, such as lower-limb prostheses. However, the unique characteristics of bionic legs warrant further investigation. The findings also hint at the potential application of bionic devices in restoring or augmenting user capabilities in diverse workplaces and future settings. Moreover, findings from study 3 show that assumptions from the SCM and behaviors as predicted by the BIAS map are observable in real-life interactions between HAT users and non-users.

Overall, the results discussed above imply several practical aspects regarding HAT users' perception, acceptance, and behaviors toward them, which are outlined in the following section.

4.1 Practical implications

Practical implications from our research refer to technology developers, employers, public awareness initiatives, and ethical considerations, aiming to enhance the responsible and beneficial integration of HATs into society.

Developers should consider the psychological impact on users, shaping more user-friendly and socially acceptable HATs by understanding how technicality levels influence social perception and self-image.

In workplace contexts, recognizing the positive effects of HAT usage on Competence and social perception is crucial. The results suggest that bionic prostheses have the potential to foster inclusivity in work settings. Consistent with these findings, users report a heightened perception of their Competence and physical capabilities. Nevertheless, organizations can facilitate inclusive environments by actively promoting acceptance and mitigating potential stigmatization, particularly for individuals using bionic prostheses.

Public awareness campaigns and education initiatives are essential to dispel stereotypes and stigmas associated with HAT users. Highlighting the diverse psychological impacts of these technologies can enable a more profound understanding of reducing societal biases.

Ethical considerations must be integral to HAT development and deployment. Clear guidelines addressing privacy concerns, consent, and broader societal implications are necessary for responsible implementation.

Considering the sustained psychological impacts over time, long-term support systems for HAT users can be beneficial. This understanding can inform the development of comprehensive support programs, addressing challenges related to dual identities and societal perceptions.

In essence, a holistic approach is vital, encompassing technological, social, and ethical considerations to ensure the responsible and beneficial integration of HATs into society.

4.2 Limitations

The dissertation at hand does not come without limitations. In the context of Studies 1 and 2, while enabling the realization of basic research with larger samples, the presentation of unmoving pictures may limit the generalizability of findings. As research indicates the presence or absence of movement significantly influences the perception of robots (Kupferberg et al., 2011), and similar effects may extend to HATs and their users. Furthermore, images featuring actual individuals introduce a subjective element influenced by personal taste and preferences, potentially impacting the participants' perception.

The corresponding samples were gathered through Prolific academic (www.prolific.co), an online sampling platform whose participants consist primarily of highly educated, younger individuals, leading to a self-selection bias in the samples. Due to resource constraints, the studies were designed in German; hence, the participants were required to have German language skills to take part in the studies, which constrained the country of origin. Consequently, the majority of the participants were from Germany, Austria, and Switzerland. Therefore, our findings may not be generalizable to other countries and cultures.

Furthermore, the measures used to assess social perception were selected based on theoretical frameworks, using both established scales and scales put together due to theoretical considerations. For Competence, items from Fiske et al. (2002) and B. Meyer and Asbrock (2018) were used. Reliability analyses showed notably unsatisfying results in both studies when the Competence items were averaged into a scale. This low reliability suggests that the items may not have coherently measured the intended construct of Competence, leading us to employ a single-item Competence measure (i.e., competent – incompetent). This decision, however, comes

with certain limitations and accounts for a significant loss of statistical power and a narrowing of the construct.

Also, as recently brought up in an integrative summary of social perception research by Abele et al. (2021), while measuring the two main dimensions without including facets may meet empirical requirements, psychometric and conceptual research has shown that incorporating differentiating facets can lead to more precise outcomes depending on the research question. Consequently, it is suggested that sub-facets should be assessed for both dimensions or incorporated into the corresponding main dimension, depending on the research query.

Study 3's limitations include a small sample exclusively comprising German-speaking individuals using upper limb prostheses. Initially gathered through convenience sampling and supplemented later with a snowballing technique, this sample may not fully represent the broader population of bionic prosthesis users and lacks generalizability across diverse cultural contexts. Additionally, the qualitative nature of the study introduces limitations inherent in personal experiences and knowledge, potentially influencing the interpretation of results. Despite rigorous methodology and good interrater reliability ($\kappa_n = .64$), the possibility of unintentional bias in the process of collecting and categorizing data has to be kept in mind, which is a common concern in qualitative research.

Finally, it has to be taken into account that reactions to this technology and self-perceptions of users of HATs are challenging to measure today, given that few people have access to this kind of technology and that some of these technologies do not exist today beyond early prototype stages. As a result, the majority of individuals do not interact with such devices first-hand, and their perceptions of them could be influenced by fictional accounts instead of

factual information (Sarda Gou et al., 2021). This fact and the limitations mentioned above should be addressed in future research, as outlined in the following paragraph.

4.3 Future research

Future research should consider the rapid evolution of HATs and their potential impact on findings, urging continuous exploration in this dynamic field. The dissertation's focus on bionic prostheses highlights the need for broader investigations into various HATs, including exoskeletons, neural interfaces, and emerging innovations. Long-term effects of HAT usage still need to be explored, necessitating follow-up studies to understand the sustainability and stability of observed psychological impacts over extended periods. Upcoming research should explicitly address augmenting devices, particularly in work-related applications like exoskeletons, to broaden our understanding of the effects of (motor) human augmentation technologies. These technologies' unintended side effects and potential benefits should be scrutinized simultaneously to inform ethical considerations and societal implications. Ethical dimensions, including privacy concerns, consent, and societal impacts, warrant deeper exploration in future studies for a comprehensive understanding. Investigating the psychological consequences of wearing bionic prostheses can provide valuable insights into the potential social implications of future human augmentation devices, contributing to the broader discourse on the evolving human-machine interface. The inclusive potential of bionic prostheses showcased in this study emphasizes the importance of accounting for unintended social consequences when introducing augmenting technologies in future work contexts. Augmenting devices, like exoskeletons, are likely to trigger similar social perception and stereotyping processes, necessitating further research to understand positive and negative outcomes in workplace settings (Gilotta et al., 2019; Siedl & Mara, 2021).

When addressing these potential research questions, future research should consider several refinements to overcome the limitations of the studies conducted so far. One is to use standardized visual stimuli to facilitate future replication studies and reduce potential bias that might arise. Different pictures of HAT users could potentially trigger attributions resulting from participants' personal preferences or prior experiences.

Also, a more robust and refined scale should be employed to assess the social perception of HATs and HAT users. For instance, a combined scale consisting of items from the Social Perception of Robots Scale (SPRS; Mandl, Bretschneider, Asbrock et al., 2022) and the Society's Attitudes Towards Human Augmentation and Performance Enhancement Technologies (SHAPE; Villa, Niess, Schmidt et al., 2023) might serve well for this purpose.

Since technologically proficient people predominantly participate in technology acceptance studies, the opinions and needs of people with a lower tendency to actively interact with novel technology may not be adequately considered. Therefore, it is essential to employ representative samples to attain inclusivity. In order to ensure that the findings of future studies are accurate and applicable to the broader population, it is important to carefully select diverse samples regarding, for instance, socioeconomic and cultural backgrounds.

Furthermore, to account for the still limited availability of HATs and the limitations that arise from static visual stimuli, upcoming research should be enriched by experimental simulation studies within an augmented reality environment that aims at the simulation of bionic prostheses developed by Rudolph et al. (2023).

A refined version of that system could also be used to research the effects of purely augmenting HATs in first and repeated encounters. This research should necessarily be complemented by research on the effects of still-existing occupational exoskeletons in praxi.

5 Conclusion

The primary research objectives of the dissertation were to investigate the psychological effects of HAT usage, explicitly focusing on bionic prostheses, and to understand how these technologies influence users' self-perception and social perception. The dissertation aimed to contribute empirical evidence on HAT usage's social and psychological impacts, addressing the user's perspective and how others perceive individuals using such technologies. The mixed-methods approach, comprising experimental studies and qualitative interviews, aimed to explore the dimensions of Competence, Sociability, and Morality in the social perception of users. Additionally, the dissertation sought to assess the potential positive and negative consequences of HAT usage, shedding light on issues such as stigmatization and the dual identity of users in different contexts.

The presented findings suggest that the level of technical sophistication or the restored functionality of bionic devices plays a pivotal role in shaping how others perceive individuals, encompassing dimensions of Warmth, Sociability, Morality, and Competence. HATs significantly impact the stereotypical social perception of their users, enhancing perceived Competence and potentially fostering greater acceptance in professional settings (Vornholt et al., 2013). However, the reliance on these devices may also entail unintended consequences, such as potential stigmatization, necessitating further investigation. Similar implications are anticipated for augmenting devices like exoskeletons (Gilotta et al., 2019; Siedl & Mara, 2021), which serve both restorative and augmentative purposes across diverse contexts (Spada et al., 2018). These technologies possess the potential to blur distinctions between human actors and HATs in everyday scenarios.

The interviews unveiled a consistent association between wearing their prosthesis and heightened feelings of Competence among users. Furthermore, participants reported observing behavioral changes in others, aligning with the predictions of the BIAS Map.

However, critical aspects of HAT proliferation demand further investigation. Inconsistencies in prior findings regarding psychological processes and potential adverse effects, the generalization of results to augmenting devices like exoskeletons, and the lack of understanding regarding repeated encounters between users and non-users of HATs necessitate addressing these gaps in future studies. Given that availability remains limited, research should be conducted in experimental settings, augmented reality contexts, and, whenever possible, real-life environments.

In summary, despite its limitations and its necessarily narrowed focus on restorative motor HATs (i.e., bionic upper-limb prostheses), this dissertation offers novel insights into a field that holds significant importance for both researchers and society in the future.

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II. RESEARCH PAPER

Embodied Digital Technologies: First Insights in the Social and Legal Perception of Robots and Users of Prostheses

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Abstract

New bionic technologies and robots are becoming increasingly common in workspaces and private spheres. It is thus crucial to understand concerns regarding their use in social and legal terms and the qualities they should possess to be accepted as ‘co-workers’. Previous research in these areas used the Stereotype Content Model to investigate, for example, attributions of Warmth and Competence towards people who use bionic prostheses, cyborgs, and robots. In the present study, we propose to differentiate the Warmth dimension into the dimensions of Sociability and Morality to gain deeper insight into how people with or without bionic prostheses are perceived. In addition, we extend our research to the perception of robots. Since legal aspects need to be considered if robots are expected to be ‘co-workers’, for the first time, we also evaluated current perceptions of robots in terms of legal aspects. We conducted two studies: In study 1, participants rated visual stimuli of individuals with or without disabilities and low- or high-tech prostheses, and robots of different levels of Anthropomorphism in terms of perceived Competence, Sociability, and Morality. In study 2, participants rated robots of different levels of Anthropomorphism in terms of perceived Competence, Sociability, and Morality, and additionally, Legal Personality, and Decision-Making Authority. We also controlled for participants’ personality. Results showed that attributions of Competence and Morality varied as a function of the technical sophistication of the prostheses. For robots, Competence attributions were negatively related to Anthropomorphism. Perception of Sociability, Morality, Legal Personality, and Decision-Making Authority varied as functions of Anthropomorphism. Overall, this study contributes to technological design, which aims to ensure high acceptance and minimal undesirable side effects, both with regard to the application of bionic instruments and robotics.

Additionally, first insights into whether more anthropomorphized robots will need to be considered differently in terms of legal practice are given.

Keywords: legal perception, social perception, robots, bionics, prosthetics, anthropomorphism, stereotypes

Introduction to Social Perception of Embodied Digital Technologies

Social Perception influences social interaction in societies (Cuddy et al., 2008). Hybrid Societies include human actors and Embodied Digital Technologies (EDTs). These societies are not a thing of the distant future anymore. Bionics users are becoming common, as are robots in workspace settings. The perception of these new kinds of actors, and their subsequent roles and acceptance within a society, is the focus of current studies.

The Stereotype Content Model (SCM; Fiske et al., 2002) identifies Warmth and Competence as the two major dimensions of Social Perception and stereotyping. Social groups can be categorized on these dimensions, for example, housewives are perceived as warm, but incompetent, while feminists are perceived as cold, but competent (Fiske et al., 2002). In the context of Hybrid Societies, Meyer and Asbrock (2018) showed that bionic prostheses affect attributions of Warmth and Competence towards their users. When using bionic prostheses, the perception of people with disabilities changes. They regain perceived Competence while maintaining the warmer perception of people with disabilities without bionic prostheses. Users of bionic technologies who aim at augmenting their capabilities rather than at restoring functionalities are sometimes described as cyborgs. Cyborgs are perceived as colder and more competent than their purely human counterparts (Meyer & Asbrock, 2018). In the current manuscript, our aim is to not only replicate these findings, but also to extend them to the perception of robots. We see the step from cyborgs to robots as an abstraction. Where cyborgs are inherently human, robots lose these qualities. The absence of these qualities affects their perception in terms of Warmth and Competence, and subsequently, their acceptance. This is important mainly within the context of workspaces. The number of robots is steadily increasing, e.g., from 18,800 in 2010 to 30,000 in 2020 for Germany (Statistisches Bundesamt, 2021).

Industrial settings were the first areas where robots were utilized to assist and, in some cases, replace human workers (Ben-Ari & Mondada, 2018). Already in the 1980s, robot implementation programs evoked mixed reactions. Low-skill workers reacted more negatively than high-skill workers to robots (Chao & Kozlowski, 1986). Dealing with the (social) issues surrounding human-robot co-working is a crucial success factor for the industry of the future (Demir et al., 2019). Different preferences for working with robots might also be associated with the perception of robots (cf., Davis 1989).

Recently, Abele et al. (2021) raised critique at the two-dimensional approach of the Stereotype Content Model. This led us to include a third dimension of Social Perception, namely Morality, in the present study. We assume that with the incoming of robots in work- and private spheres, legal adjustments need to be considered, and subsequently accepted by the public. To extend previous findings for users of different prosthesis types (Meyer & Asbrock, 2018) to social robots, two studies addressed three

major research questions.

1) How does the public perceive people with disabilities, different types of prostheses as well as different types of robots regarding Competence, Sociability, and Morality?
2) How are personality factors associated with these perceptions?
3) How are different types of robots perceived in terms of Legal Personality and Decision Making Authority?

Dimensions of Social Perception

To examine the core dimensions of Social Perception in this context, we employ the Stereotype Content Model (SCM; Fiske et al., 2002) as a theoretical fundament. The Stereotype Content Model originates in social cognition research and has become one of the most prominent

theoretical models on Social Perception. It is applied to describe intergroup and interpersonal perception and to understand the perception of consumer brands or artificial intelligence (McKee et al., 2021). The Stereotype Content Model postulates that all group stereotypes and interpersonal impressions are formed on two fundamental dimensions. These are Warmth (from cold = bad intentions to warm = good intentions) and Competence (from incompetent to competent), resulting in four possible combinations. Persons or groups perceived as warm and incompetent evoke emotions like pity or compassion and elicit active facilitation (help, patronize) as a behavioral correlate. Conversely, people perceived as cold and competent trigger emotions like envy or mistrust that are accompanied by passive harm, for example, ignorance or sabotage (Cuddy et al., 2008). Despite being well established and empirically tested in numerous studies, the Stereotype Content Model has been criticized due to its twodimensionality (Abele et al., 2021). Regularly, Morality, in the original model included in Warmth (Fiske, 2018), has been brought up as a third factor. This can be achieved by dividing Warmth into two subdimensions of Morality and Sociability (Kervyn et al., 2015; Leach et al., 2007). Accordingly, we divided Warmth into Sociability and Morality. Sociability covers how a person or robot is perceived in terms of Likeableness and Warmth. Morality covers how a person or robot is perceived in terms of their intentions to act immoral or moral. The importance of Morality on functioning societies is indisputable (Hannah et al., 2011), an integration of this dimension will therefore enlarge former findings.

Social Perception of People with Disabilities

Users of bionic prostheses are perceived as more competent than people with disabilities. They maintain perceived Warmth of people with disabilities, that is, they are perceived as warmer than able-bodied individuals (Meyer & Asbrock, 2018). These findings can also be applied to another

groundbreaking development: Bionic instruments are used to reestablish or expand the capacities of their users by merging human bodies with technological artifacts to serve a particular purpose. Concerning current augmenting devices, for example, exoskeletons, first results indicate that they are also highly likely to influence the self- and other perception of potential users. Peters and Wischniewski (2019) point out that users may likely perceive themselves as inferior while using an exoskeleton when fulfilling their daily work routines. Wearing an exoskeleton may also lead to stigmatization in the workplace because the user appears dependent on a technological artifact to co-workers (Gilotta et al., 2019; Peters & Wischniewski, 2019). In short, the use of bionic technologies can affect stereotypes towards their users and is also likely to affect interpersonal perceptions on the individual and group level.

Social Perception of Robots

Bionic devices are highly likely to be prevalent in the near future. Robots have become increasingly common in workspaces and will be expected to act as ‘co-workers’ (Demir et al., 2019). Furthermore, robots will be introduced into private spaces. This presupposes that people want and accept robots in their homes. To be accepted, robots need to possess certain qualities. Whether these qualities can be derived from qualities human beings possess or are attributed is still under debate and needs further consideration. Prior research on the Social Perception of robots using the Robotic Social Attributes Scale (RoSAS; Carpinella et al., 2017) showed that traits similar to the humane perceptions of Warmth and Competence can be ascribed to robots. Both dimensions are also the most important predictors for human preferences concerning different robot behaviors (Scheunemann et al., 2020). Especially in industrial settings, robots are seen as social entities and attributed positive and negative humanlike characteristics (Sauppé & Mutlu, 2015). Perception of robots are also influenced by other aspects such as its design or size

(de Visser et al., 2016; Li et al., 2010; Rosenthal-von der Pütten, 2014; Schaefer et al., 2012; von der Pütten & Krämer, 2012). Industrial robots might be exempt from this since their appearance needs to conform to measures of safety and usability (Gesmann-Nuissl, 2019). Whereas anthropomorphic features elicit greater trust (de Visser et al., 2016), too close resemblance to actual human beings might have the opposite effect. The uncanny valley phenomenon (Mori et al., 2012) describes how extraordinarily human-like robots are perceived. Mostly, they are seen as rather eerie and elicit feelings of uneasiness or threat. Therefore, the question of 'how human-like is too human-like' is not trivial at all and needs closer inspection. We see this study as groundwork to investigate which qualities a robot should possess to be an accepted partner in a hybrid society. Hence, we focus on the expanded Stereotype Content Model, and investigate whether or not inherently humane properties can be attributed to robots. Against the background of increased research focused on moral machines (Awad et al., 2018; Bigman et al., 2019; Cervantes et al., 2020), we assess Morality to examine if and to what extent people are willing to attribute Morality to robots. Acceptance of robots is not solely explained by the robots' appearance or behavior, but also by a persons' preference and the subsequent appliance of it. The Technology Acceptance Model (TAM; Davis, 1989) is a theoretical model of how characteristics of computer-based information systems influence user acceptance and subsequent use of these systems. The model considers external variables, such as perceived usefulness and perceived ease of use which influence the attitude towards and behavioral intention to and actual use of a system. It points out that both usefulness and ease of use is founded within the user (Davis, 1989). This implies that personality factors might be associated with how well a system, in our case a robot, is integrated into workspaces and subsequently into society, but necessarily also in the legal system.

Individual Differences in Social Perception

We considered a broad range of personality variables associated with the perception of others. Since we are assessing the perceived Morality of others, we considered personality factors which were shown as core variables to be associated with moral behavior (Strobel et al., 2017). Affinity for Technology Interaction (ATI) is the tendency to actively engage in intensive technology interaction (Franke et al., 2019). People who show positive interest in technical gadgets are more likely to interact with and accept robots (Heerink, 2011; de Graaf & Ben Allouch, 2013). Technological affinity is negatively correlated with perceived ease of use as specified in the Technology Acceptance Model (Davis, 1989). It can be assumed that people high in technological affinity have a clearer picture of what a robot can or cannot do. Technological orientation is connected with Robot Acceptance at Work (RAW) through two factors: on an individual level, for example, daily internet use at work, and on a national level, for example, larger mobile phone ratio (Turja & Oksanen, 2019). Affinity for Technology Interaction (Franke et al., 2019) and Need for Cognition (NFC; Cacioppo & Petty, 1982), as well as computer experience (Dijkstra et al., 1998), are moderately to strongly positive correlated. Need for Cognition is defined as the tendency of an individual to engage in and enjoy thinking (Cacioppo & Petty, 1982). Need for Cognition has a strong impact on the perception of Anthropomorphism of robots. People high in Need for Cognition tend to anthropomorphize less than people low in Need for Cognition. This is due to differences in the accessibility of egocentric information. Individuals higher in Need for Cognition more readily apply nonanthropomorphic attributions while those, lower in Need for Cognition, rather use anthropomorphic attributions (Epley et al., 2007). This results in differences, especially when attributing characteristics of Agency,

Sociability, and Animacy to robots (Spatola & Wykowska, 2021). Need for Cognition and Openness are investment traits. They determine where and in which amount people invest cognitive effort over time (von Stumm, 2013). When interacting with robots, the personality trait of Openness should be considered influential. Individuals high in Openness are, for example, inquisitive about various domains of knowledge, and take an interest in unusual ideas or people (Ashton & Lee, 2009). Openness facilitates the interaction with robots in such a way that it significantly correlates with robot-led cognitive testing of elderly people (Rossi et al., 2020). This suggests that by being receptive to new ideas and experiences, the novelty of robots triggers curiosity rather than anxiety.

Possible associations between personality variables and acceptance of robots is a rather new topic. At this background, we decided to include not only Openness as a dimension of the HEXACO model (Ashton & Lee, 2009), but to investigate all dimensions (i.e., Honesty-Humility, Emotionality, Extraversion, Agreeableness, Conscientiousness, and Openness) on an exploratory basis. By using the HEXACO model (Ashton & Lee, 2009), we can include the Big Five Personality Dimensions (e.g., McCrae & Costa, 1987) and the dimension of Honesty-Humility. Honesty-Humility is associated with moral aspects. The initial implication of Openness as being curious about new things can be widened to being open and willing to emphasize with others. Empathy describes the ability to understand and react adequately to others (Paulus, 2009). Empathy includes the subfacets Perspective Taking (i.e., being able to change psychological perspective spontaneously), Fantasy (i.e., being able to empathize with fictional characters), Empathic Concern (i.e., compassion and worry for people in need), and Personal Distress (i.e., self-focused emotional reactions). Higher levels of Empathy are linked to the tendency to perceive robots as fellow social agents rather than unfeeling machines (Rossi et

al., 2020; Mattiassi et al., 2021). Links between familiarity with and empathic responses to robots were proposed (Mattiassi et al., 2021). Justice Sensitivity describes how people vary in how easily they perceive injustice and how strongly they react to it. These differences are stable across time and different situations (Schmitt et al., 2009). Justice Sensitivity covers four perspectives: Victim Sensitivity, Observer Sensitivity, Beneficiary Sensitivity, and Perpetrator Sensitivity (Beierlein et al., 2014). Differences in Justice Sensitivity could also have implications for what legal competencies people associate with robots. Moral Identity is one kind of social identity people use to construct self-definition which in turn is associated with moral action (Aquino & Reed, 2002). Moral Identity covers two subscales, namely Internalization and Symbolization. The dimension of Internalization depicts the self-importance of the moral characteristics. The dimension of Symbolization depicts a general sensitivity to how the moral self is perceived in terms of their actions in the world (Aquino & Reed, 2002). We included Justice Sensitivity and Moral Identity to take into account the possibility that especially social robots, designed to be companions for users, might deserve moral consideration. The question of moral standing might therefore be answered differently for these robots (Scholtz, 2010; Coeckelbergh, 2021).

The Present Studies: Social and Legal Perception of Embodied Digital Technologies

In two studies, we aimed at replicating and extending previous findings (Meyer & Asbrock, 2018) on the Social Perception of Embodied Digital Technologies. In study 1, we analyzed the Social Perception of people with prostheses varying in technicality as well as robots, taking into account individual differences. In study 2, we aimed at replicating the findings of the study 1 for robots and widened the scope by including legal attributions to robots. We will establish our Hypotheses and Research Questions related to legal attributions in the introduction for study 2.

Social Perception varies across the dimensions of the Stereotype Content Model for people with prostheses of differing types (Meyer & Asbrock, 2018; Peters & Wischniewski, 2019). We, therefore, hypothesized in study 1:

H1: People with physical disabilities who use low-tech prostheses are generally seen as less competent than people with physical disabilities who use bionic prostheses or ablebodied individuals.

We widened the scope of the Stereotype Content Model by dividing the dimension of Warmth into Sociability and Morality, following Leach et al.'s (2007) line of argumentation. We assessed how people with physical disabilities who use low-tech prostheses, people with physical disabilities who use bionic prostheses, and able-bodied individuals were perceived in general in terms of 1) Sociability, and 2) Morality (RQ1).

We expected personality variables to be associated with the Social Perception of people with physical disabilities with different kinds of prostheses. Hence, we investigated if there is an association between personality variables and the perception of people with physical disabilities who use low-tech prostheses, people with physical disabilities who use bionic prostheses, and able-bodied individuals in terms of 1) Competence, 2) Sociability, and 3) Morality (RQ2).

Furthermore, we expanded these research questions to robots to evaluate their current perception in general. We evaluated how robots with varying levels of Anthropomorphism were perceived in terms of 1) Competence, 2) Sociability, and 3) Morality (RQ3) and whether there was an association between personality variables and the perception of robots with varying levels of Anthropomorphism in terms of 1) Competence, 2) Sociability, and 3) Morality (RQ4).

Since this is one of the first studies to approach robot perception with mostly humane attributions, we evaluated whether uniquely humane adjectives could be used to describe robots with varying levels of Anthropomorphism (RQ5).

Study 1: Social Perception of Embodied Digital Technologies

Prior to data collection, the present study was preregistered on OSF (https://osf.io/xevkp). The procedure was evaluated and approved by the Ethics Committee. It was not considered to require further ethical approvals and hence, as uncritical concerning ethical aspects according to the criteria used by the Ethics Committee, which includes aspects of the sample of healthy adults, voluntary attendance, noninvasive measures, no deception, and appropriate physical and mental demands on the subject.

Methods

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study (Simmons et al., 2012).

Participants. We conducted an a-priori-power analysis with G*Power (version 3.1.9.6; Faul et al., 2007) for one-way ANOVA with fixed effects. A medium effect size of 0.25 was assumed and power set to 0.95, resulting in a sample size of $N = 462$. The sample was acquired via Prolific academic (www.prolific.co), an online survey platform (Palan & Schitter, 2018). We conducted a pilot study ($N = 30$) to assess the mean processing time. By including a manipulation check, we were able to exclude participants who did not read the instructions carefully and of whom we would expect their data to be flawed. Three participants did not meet the requirements of the manipulation checks and were therefore excluded, resulting in a final sample size of $N = 459$. We checked for outliers that were specified at having rated the social dimensions outside of ± three standard deviations from the mean and ran analyses twice: once by

including and once by excluding the outliers. The results did not differ from each other, which is why for further analyses, all participants are considered. The mean age of the sample was $M = 30.02$ ($SD = 9.77$). The sample consisted of 205 female, 246 male, and eight non-binary participants and was mostly highly educated, with 47.06% having obtained a university degree (high-school diploma: 32.90%, other degrees: 19.39%, no degree: 0.65%). Countries of residence of the participants were mainly Germany (72.77%), Austria (8.06%), and Switzerland (3.27%), with 15.90% residing in other countries.

Measures.

Stimulus Material. The stimulus material consisted of 11 pictures of human beings with and without low- and high-tech prostheses, and different robots. All materials can be found on osf (www.osf.io/xsn5a). To account for different types of disabilities and prostheses, three types of disabilities (one arm, one leg, both legs) were shown. For each disability, a low- and high-tech-type prosthesis were presented. Two able-bodied individuals, one female and one male, were shown. The pictures were chosen according to the following criteria: neutral to slightly positive facial expression, neutral clothing, neutral background. People with prostheses were exclusively male to control for the influence of female stereotypes. We presented three robots with different levels of Anthropomorphism as stimulus material: On the lowest level an industrial robot, which does not possess any human-like qualities, such as a face. On the second level, a social robot (Pepper, SoftBank Robotic Europe), which possesses a face with eyes and a mouth, and its form resembles a typical human body with head, body, and arms. The highest level of Anthropomorphism is represented by an android robot, a still image taken from the movie ROBOLOVE (Arlamovsky, 2019), which is almost indiscernible from a human being. We presented the industrial robot in a typical setting and the others in neutral settings. All pictures

were presented in randomized order with instructions to rate how the participants perceive the person/robot, how they think the person/robot would act/think/react, even though this first impression might be wrong and revoked later. Twenty-five adjectives on opposing ends of a semantic differential were presented in randomized order, to be rated on a five-point Likert scale (e.g., competent-incompetent, warm-cold, artificial-natural, animated-indifferent, polite-impolite, moral-immoral, see Items). For the pictures of robots, two additional choices were given in accordance with Chita-Tegmark et al. (2021): 'does not apply to robots in general' and 'does not apply to this specific robot'.

Items. We composed items to cover the three main dimensions Competence, Sociability, and Morality, as well as Anthropomorphism, rated on a five-point Likert scale.

Competence: We chose four items to cover Competence (e.g., *competent*, *able*) in line with previous studies (e.g., Fiske, 2018; Fiske et al., 2002; Meyer & Asbrock, 2018), and averaged these items into a scale (McDonald's Omega = .71).

Sociability: We assessed Sociability with three subscales: Warmth (three items; e.g., *warm*) (Fiske, 2018; Fiske et al., 2002; Meyer & Asbrock, 2018), Animacy (three items; e.g., *interactive*), and Likeability (two items; e.g., *friendly*), the latter two subscales taken from the Godspeed Questionnaire (Bartneck et al., 2009), resulting in a total of eight items for the Sociability scale. We averaged these items into a scale (McDonald's Omega = .85).

Morality: We adapted eight attributions which people high in Moral Identity possess of the German version of the Moral Identity Questionnaire (Aquino & Reed, 2002) based on theoretical considerations, that is, intelligibility and relevance, and chose corresponding antonyms to use for the present study (e.g., *ethical*). We averaged these items into a scale (McDonald's Omega = .78).

Anthropomorphism: We used five items from the Godspeed Questionnaire (Bartneck et al., 2009) to assess perceived Anthropomorphism of the robots (e.g., *humanlike*). We averaged these items into a scale (McDonald's Omega = .88).

Affinity for Technology Interaction: We used the German version of the Affinity for Technology Interaction (ATI) Scale (Franke et al., 2019). Nine items were rated on a six-point scale (anchored at *not true at all* and *very true*) to indicate whether people tend to act with technological systems (e.g., *I like to try out functions of new technical systems*) and averaged into a scale (Table 1).

Need for Cognition: We used the German short version of the Need for Cognition (NFC) scale (Bless et al., 1994), comprising of sixteen items (e.g., *I consider finding new solutions to problems a fun activity*), to assess NFC. The items were rated on a seven-point scale, anchored at *1 = strong disagreement* and *7 = strong agreement*. We calculated a sum score (Table 1).

HEXACO Personality Dimensions: The HEXACO Personality Inventory (Ashton & Lee, 2009) consists of six scales: Honesty-Humility (H), Emotionality (E), Extraversion (X), Agreeableness (A), Conscientiousness (C), and Openness to Experience (O). For the present study, we used the 60-item version which includes 10 items for each dimension (e.g., *Having a lot of money is not especially important to me* (H), *I sometimes can't help worrying about little things* (E), *I feel reasonably satisfied with myself overall* (X), *I tend to be lenient in judging other people* (A), *I often push myself very hard when trying to achieve a goal* (C), *I like people who have unconventional views* (O)), rated on a five-point scale, anchored at *1 = strongly disagree* and *5 = strongly agree*. We averaged items of the corresponding scales (Table 1).

Empathy: We used the Saarbrücker Personality Questionnaire SPF (IRI) (Paulus, 2009) for assessing empathy. The SPF is the German version of the Interpersonal Reactivity Index

(IRI) and consists of four scales: Perspective Taking (PT), Fantasy (FS), Empathic Concern (EC), and Personal Distress (PD), each of which is assessed by four items (e.g., *In emergencies, I feel anxious and uncomfortable* (PD), *I can imagine feelings of a fictional person in a book really well* (FS), *I believe that every problem has two sides and try to take both into account* (PT), *I am touched by things even if I only observe them* (EC)). These items are rated on a five-point scale (*1 = never*, *2 = seldom*, *3 = sometimes*, *4 = often*, *5 = always*) whether this statement applies to the participant. EC, FS, and PD cover an emotional, PT a cognitive empathy factor. We averaged items of the four scales (Table 1).

Injustice Sensitivity: We measured Injustice Sensitivity with the German short scales USS-8 (Ungerechtigkeitssensibilität-Skalen-8, Beierlein et al., 2014), which covers four perspectives (Beneficiary Sensitivity (BS), Observer Sensitivity (OS), Perpetrator Sensitivity (PS), and Victim Sensitivity (VS.)) with two items per perspective (e.g., *I feel guilty when I am better off than others for no reason* (BS), *I am upset when someone is undeservingly worse off than others* (OS), *I feel guilty when I enrich myself at the cost of others* (PS), *It makes me angry when others are undeservingly better off than me* (VS.)), which are rated on a 6-point scale anchored at *1 = not at all* and *6 = exactly*. We averaged items per perspective (Table 1).

Moral Identity: We measured Moral Identity with the German Moral Identity Scale (Aquino & Reed, 2002), which includes two subscales, Internalization and Symbolization. Nine attributions (e.g., *honest*, *friendly*, *fair*) are presented and participants have to imagine a person with these qualities. Five items per scale are rated on a seven-point scale anchored at *1 = strongly disagree* and *7 = strongly agree* (e.g., T*o be someone with these attributes is an important part of me* (Internalization), *I often wear clothes which identify me as someone with these attributes* (Symbolization)). We averaged the items of the respective subscales (Table 1).

Table 1

Reliability Analyses and Descriptives of Personality Variables

Scale	Subscale	Study 1 (N = 459)			Study 2 (N = 433)		
		M	*SD*	McDonald's Omega	*M*	*SD*	McDonald's Omega
ATI	-	4.25	1.01	.93	4.15	0.96	.92
NFC	-	14.17	15.51	.91	12.58	14.44	.91
HEXACO	Honesty-Humility	3.33	0.65	.74	3.41	0.62	.75
	Emotionality	3.13	0.69	.81	3.12	0.62	.79
	Extraversion	2.95	0.72	.84	3.09	0.60	.80
	Agreeableness	3.21	0.56	.73	3.10	0.50	.69
	Conscientiousness	3.56	0.59	.77	3.65	0.52	.75
	Openness	3.59	0.59	.72	3.47	0.64	.77
SPF	Empathic Concern	3.48	0.68	.72	3.44	0.61	.72
	Fantasy	3.44	0.72	.72	3.39	0.69	.75
	Personal Distress	2.73	0.77	.74	2.74	0.77	.81
	Perspective Taking	3.61	0.63	.76	3.59	0.63	.76
	Victim Sensitivity	3.73	1.28	.78	3.63	1.30	.86
Injustice Sensitivity (USS-8)	Observer Sensitivity	4.10	1.22	.78	3.79	1.16	.81
	Beneficiary Sensitivity	3.08	1.42	.88	2.92	1.25	.89
	Perpetrator Sensitivity	4.32	1.29	.74	4.16	1.34	.87
Moral Identity Scale	Internalization	5.70	0.91	.80	5.39	0.94	.79
	Symbolization	3.64	1.08	.72	3.78	1.04	.79

Note. ATI = Affinity for Technology Interaction, potential range = 1 to 6; NFC = Need for Cognition, potential range = -48 to +48; HEXACO, potential range = 1 to 5; SPF = Saarbrücker Personality Inventory, potential range = 1 to 5; USS-8 = Injustice Sensitivity Scales-8, potential range = 1 to 6; Moral Identity Scale, potential range = 1 to 7.

Procedure. The study was conducted as an online survey via Prolific Academic. Data were collected with Limesurvey. After giving informed consent and filling in a sociodemographic questionnaire, participants first completed the HEXACO-PI-R questionnaire (Ashton & Lee, 2009). Next, the stimulus material was presented and the participants rated each of the eleven pictures on 25 adjectives that comprised the six scales Competence, Warmth, Anthropomorphism, Animacy, Likeability, and Morality. Afterward, participants completed the five additional personality questionnaires presented in randomized order. Lastly, we asked whether the participants themselves or any of their acquaintances used prostheses. Upon finishing, participants were forwarded to Prolific Academic (http://www.prolific.co) to receive a compensation of EUR 3.60. The total processing time was approximately 30 min.

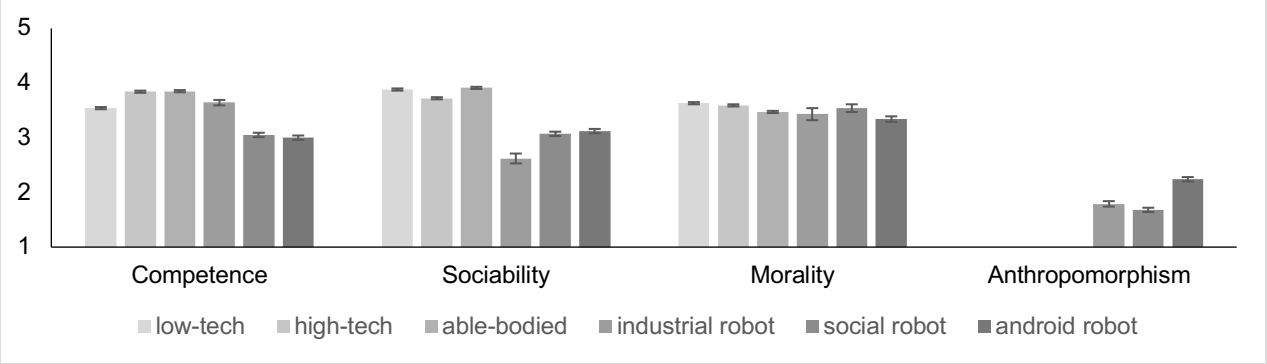
Statistical Analysis. Each participant rated all eleven pictures. These eleven repeated measurements of the dependent variables were thus nested in participants; this was the case for Competence, ICC(1) = .13, $F_{(458, 1944)} = 1.75$, $p < .001$, ICC(2) = .43, Sociability, ICC(1) = .16, $F_{(458, 1526)} = 1.80$, $p < .001$, ICC(2) = .44, Morality, ICC(1) = .51, $F_{(458, 1106)} = 4.53$, $p < .001$, ICC(2) = .78. We thus employed Mixed Models to account for nested data. We used R (Version 4.1.1; R Core Team, 2021) and the Rpackages dplyr (Version 1.0.7), tidyverse (Version 1.3.1), tidyr (Version 1.1.3), forcats (Version 0.5.1) for data management, psych (Version 2.1.6), sjstats (Version 0.18.1), ggpubr (Version 0.4.0), sjplot (Version 2.8.9), lm.beta (Version 1.5–1), apaTables (Version 2.0.8), and ggplot2 (Version 3.3.5) for descriptive analyses, MuMln (Version 1.43.17), effects (Version 4.2–0), emmeans (Version 1.6.2.1), mulitlevel (Version 2.6), stats (Version 4.0.2), lme4 (Version 1.1–27.1), pbkrtest (Version 0.5.1) and lattice (Version 0.20–44) for fitting Mixed Models and subsequent post-hoc testing.

Results

Visual inspection of the data revealed non-linear relationships between Competence, Sociability, and Morality, and Grade of Technicity, respectively. To account for the apparent break between human and robotic stimuli, we decided to split the data for all three attributions into two subgroups. The data structure for human stimuli revealed that instead of Grade of Technicity, Restored Function seemed to explain differences in attributions better. We rearranged the data from low-tech prostheses to bionic prostheses to able-bodied individuals. This was also in accordance with our Hypothesis 1 and Research Questions. For Sociability and Morality, fewer participants attributed the respective adjectives to robots (see Figure 1).

Figure 1

Estimated Marginal Mean Scores for Grades of Technicity and Social Perception



Note. $N = 459$; Competence: $n_{\text{industrial robot}} = 324$, $n_{\text{social robot}} = 355$, $n_{\text{android robot}} = 347$; Sociability: $n_{\text{industrial robot}} = 41$, $n_{\text{social robot}} = 263$, $n_{\text{android robot}} = 304$; Morality: $n_{\text{industrial robot}} = 22$, $n_{\text{social robot}} = 66$, $n_{\text{android robot}} = 100$; Anthropomorphism: $n_{\text{industrial robot}} = 181$, $n_{\text{social robot}} = 233$, $n_{\text{android robot}} = 277$. Error bars show Standard Errors.

We fitted three Mixed Models with random intercepts and slopes for the variables Competence, Sociability, and Morality for both subgroups (able-bodied individuals, users of low- and high-tech

prostheses, and industrial, social, and anthropomorphic robots). We controlled for participants' age, gender, and education in all models. We correlated personality dimensions of the HEXACO model, Affinity for Technology Interaction (ATI), Need for Cognition (NFC), Empathy, Injustice Sensitivity, and Moral Identity with perceptions of Competence, Sociability, and Morality for both subgroups and adjusted for multiple comparisons (Holm, 1979).

Human Stimuli. Hypothesis 1 predicted that users of low-tech prostheses are perceived as less competent than users of bionic prostheses and able-bodied individuals. We tested the hypothesis in a Mixed Model regressing Competence on Restored Functionality (RF). A model with random intercepts and slopes fit the data best (Table 2).

We found that RF was positively associated with perceptions of Competence. Post-hoc Tukey tests showed that users of low-tech prostheses were perceived as significantly less competent than users of high-tech prostheses, $\Delta M = -0.30$, $SE = 0.04$, $t = -7.59$, $p < .001$, and as less competent than able-bodied individuals, $\Delta M = 0.31$, $SE = 0.04$, $t = 8.01$, $p < .001$. Perceived Competence did not differ significantly between users of high-tech prostheses and able-bodied individuals, $\Delta M = 0.02$, $SE = 0.04$, $t = 0.42$, $p = .998$. Female participants attributed significantly more Competence to individuals with and without low- and high-tech prostheses than male participants, $b = 0.17$, $SE = 0.04$, $t = 3.79$. Education was negatively associated with attributed Competence, $b = -0.05$, $SE = 0.02$, $t = -2.96$. Research Question 1 was concerned with perceptions of users of high- and low-tech prostheses and able-bodied individuals in terms of Sociability and Morality. Perceived Sociability was not associated with Restored Functionality (Table 3). Perceived Morality was negatively associated with RF (Table 4). Post-hoc Tukey tests revealed that able-bodied individuals were attributed significantly less Morality than users of low-tech prostheses, $\Delta M = 0.16$, SE = 0.02, $t = 9.14$, $p < .001$, and users of high-tech prostheses,

ΔM= 0.12, *SE* = 0.02, *t* = 6.77, *p* < .001. Between users of high- and low-tech prostheses, the difference in perceived Morality revealed a trend toward a difference between technicity of the prostheses only on a descriptive level, Δ*M* = 0.04, *SE* = 0.02, *t* = 2.37, *p* = .050. Attributions of neither Sociability nor Morality were associated with the control variables.

Table 2

Comparison of Fit Indices for Linear Mixed Models regressing Competence on Restored Functionality for human stimuli

Predictors	Model 0			Model 1			Model 2			Model 3		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
(Intercept)	3.83	0.02	<.001**	3.43	0.03	<.001**	3.43	0.03	<.001**	4.15	0.13	<.001**
RF				0.16	0.01	<.001**	0.16	0.01	<.001**	0.16	0.01	<.001**
Gender										-0.24	0.04	<.001**
Education										-0.05	0.02	.003**
Age										-0.00	0.00	.207
Random Effects												
σ^2	0.15			0.13			0.10			0.10		
τ_{00}	0.14 $_{id}$			0.15 $_{id}$			0.26 $_{id}$			0.24 $_{id}$		
τ_{11}							0.03 $_{id.rf}$			0.03 $_{id.rf}$		
ρ_{01}							-0.62 $_{id}$			-0.62 $_{id}$		
ICC	.49			.55			.65			.63		
Model fit												
Marginal R^2	0.000			0.055			0.055			0.112		
Condi-tional R^2	0.490			0.572			0.671			0.673		
AIC	1927.5			1774.1			1752.0			1737.6		
BIC	1943.2			1795.0			1783.4			1784.7		
χ^2				155.39**			26.09**			20.39**		

Note. *N* = 459, Observations = 1377; RF = Restored Functionality.

* *p* < .05. ** *p* < .01.

Table 3

Comparison of Fit Indices for Linear Mixed Models regressing Sociability on Restored Functionality for the subgroup of human stimuli

Predictors	Model 0			Model 1			Model 2		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
(Intercept)	3.83	0.02	<.001**	3.80	0.03	<.001**	4.36	0.13	<.001**
RF				0.02	0.01	.100	0.02	0.01	.100
Gender							-0.17	0.04	<.001**
Education							-0.02	0.02	.228
Age							-0.01	0.00	.002**
Random Effects									
σ^2	0.10			0.10			0.10		
τ_{00}	0.15 $_{id}$			0.15 $_{id}$			0.14 $_{id}$		
ICC	.60			.60			.59		
Model Fit									
Marginal R^2	0.000			0.001			0.044		
Conditional R^2	0.604			0.604			0.606		
AIC	1475.0			1481.6			1481.3		
BIC	1490.7			1502.5			1517.9		
χ^2				0.00			6.35		

Note. N = 459, Observations = 1377; RF = Restored Functionality.

*p < .05. **p < .01.

Table 4

Comparison of Fit Indices for Linear Mixed Models regressing Morality on Restored Functionality for human stimuli

Predictors	Model 0			Model 1			Model 2			Model 3		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
(Intercept)	3.56	0.02	<.001**	3.72	0.03	<.001**	3.72	0.03	<.001	4.25	0.12	<.001**
RF				-0.08	0.01	<.001**	-0.08	0.01	<.001	-0.08	0.01	<.001**
Gender										-0.13	0.04	<.001**
Education										-0.04	0.02	.028*
Age										-0.00	0.00	.015*
Random Effects												
σ^2	0.08			0.07			0.05			0.07		
τ_{00}	0.13 $_{id}$			0.14 $_{id}$			0.18 $_{id}$			0.13 $_{id}$		
τ_{11}							0.02 $_{id.rf}$					
ρ_{01}							-0.49 $_{id}$					
ICC	.64			.66			.74			.65		
Model fit												
Marginal R^2	0.000			0.020			0.020			0.054		
Condi-tional R^2	0.639			0.669			0.741			0.670		
AIC	1199.8			1129.8			1109.9			1115.6		
BIC	1215.5			1150.7			1141.3			1162.7		
χ^2				155.39**			26.09**			20.39**		

Note. N = 459, Observations = 1377; RF = Restored Functionality.

*p < .05. **p < .01.

Research Question 2 is concerned with associations between personality variables and attributions of Competence, Sociability, and Morality to people with low- and high-tech prostheses and able-bodied individuals (Supplementary A).

Emotionality showed a small positive correlation with attributions of Competence (r = .25) and Sociability (r = .21). Conscientiousness showed a small positive correlation with

attributed Morality (r = .17). Empathic Concern ($r_{Competence}$ = .21, $r_{Sociability}$ = .19, $r_{Morality}$ = .18), and Internalization ($r_{Competence}$ = .26, $r_{Sociability}$ = .25, $r_{Morality}$ = .21) showed small positive correlations with all three attributions of Social Perception. Attributions of Competence furthermore showed small positive correlations with Observer Sensitivity (r = .18) and Perpetrator Sensitivity (r = .20).

Robotic stimuli. Research Question 3 proposed that different levels of Anthropomorphism would be associated with different attributions of Competence, Sociability, and Morality. Answering this question first required establishing whether the different types of robots in the stimulus material were indeed perceived as having different levels of Anthropomorphism. We regressed Anthropomorphism on robot type with a corresponding Mixed Model. Indeed, perceptions of Anthropomorphism differed between robot types, b = 0.25, SE = 0.03, t = 8.44. Post-hoc Tukey tests showed that the android robot was perceived as more anthropomorphized than the industrial robot, ΔM = 0.45, SE = 0.06, t = −7.81, p < .001, and the social robot, ΔM= 0.56, SE = 0.05, t = −10.54, p < .001. The latter two, in contrast to theoretical considerations, did not differ from each other, ΔM = 0.11, SE = 0.06, t = 1.82, p = .160 (Figure 1). Having established the different levels of Anthropomorphism of the stimuli, we subsequently compared perceived Competence, Sociability, and Morality across the different robot types (RQ3). Different robots were indeed associated with different levels of attributed Competence (Table 5).

Post-hoc Tukey tests showed that the industrial robot was perceived as more competent than the social robot, ΔM= 0.58, SE = 0.06, t = 10.54, p < .001, and as more competent than the android robot, ΔM = 0.64, SE = 0.06, t = 11.51, p < .001. Perceived Competence of the social and android robot did not differ, ΔM= 0.06, SE = 0.05, t = 1.07, p = .540. Type of robot was

positively associated with perceived Sociability (Table 6). Post-hoc Tukey tests showed that the industrial robot was perceived as less sociable than both the social robot, ΔM = -0.44, SE = 0.08, t = -5.60, p < .001, and the android robot, ΔM= -0.49, SE = 0.08, t = -6.35, p < .001, while the perceptions did not differ for the social robot and the android robot, ΔM = -0.05, SE = 0.04, t = -1.43, p = .710.

Table 5

Comparison of Fit Indices for Linear Mixed Models regressing Competence on Grade of Technicity for robotic stimuli

Predictors	Model 0			Model 1			Model 2			Model 3		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
(Intercept)	3.22	0.03	<.001**	4.81	0.15	<.001**	4.81	0.15	<.001**	4.90	0.25	<.001**
GOT				-0.32	0.03	<.001**	-0.32	0.03	<.001**	-0.32	0.03	<.001**
Gender										-0.04	0.06	.512
Education										-0.00	0.00	.632
Age										0.00	0.03	.901
Random Effects												
σ^2	0.61			0.52			0.43			0.43		
τ_{00}	0.13 $_{id}$			0.16 $_{id}$			2.19 $_{id}$			2.18 $_{id}$		
τ_{11}							0.10 $_{id.got}$			0.10 $_{id.got}$		
ρ_{01}							-0.96 $_{id}$			-0.96 $_{id}$		
ICC	.18			.23			.36			.37		
Model fit												
Marginal R^2	0.000			0.088			0.089			0.089		
Conditional R^2	0.180			0.298			0.421			0.423		
AIC	2596.6			2488.5			2478.2			2502.5		
BIC	2611.4			2508.2			2507.8			2546.9		
χ^2				110.12**			14.26**			0.00		

Note. N = 404, Observations = 1026; GOT = Grade of Technicity.

*p < .05. **p < .01.

Table 6

Comparison of Fit Indices for Linear Mixed Models regressing Sociability on Grade of Technicity for the subgroup of robotic stimuli

Predictors	Model 0			Model 1			Model 2		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
(Intercept)	3.07	0.03	<.001**	2.27	0.21	<.001**	2.32	0.29	<.001**
GOT				0.15	0.04	<.001**	0.15	0.04	<.001**
Gender							0.01	0.06	.796
Education							-0.02	0.03	.464
Age							0.00	0.00	.745
Random Effects									
σ^2	0.31			0.30			0.30		
τ_{00}	0.10 $_{id}$			0.10 $_{id}$			0.10 $_{id}$		
ICC	.25			.25			.26		
Model Fit									
Marginal R^2	0.000			0.020			0.021		
Conditional R^2	0.252			0.267			0.273		
AIC	1172.8			1164.4			1188.8		
BIC	1186.1			1182.1			1219.7		
χ^2				10.40**			0.00		

Note. N = 332, Observations = 608; GOT = Grade of Technicity.

*p <.05. **p < .01.

For attributed Morality, we did not find evidence for an association with type of robot (Table 7). Research Question 4 was concerned with associations between personality variables

and attributions of Competence, Sociability, and Morality to robots. Correlational analyses revealed no significant associations (Supplementary B).

Table 7

Comparison of Fit Indices for Linear Mixed Models regressing Morality on Grade of Technicity for the subgroup of robotic stimuli

Predictors	Model 0			Model 1			Model 2		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
(Intercept)	3.42	0.05	<.001**	3.93	0.29	<.001**	4.11	0.42	<.001**
GOT				-0.09	0.05	.070	-0.09	0.05	.085
Gender							-0.12	0.09	.160
Education							0.05	0.04	.222
Age							-0.01	0.00	.058
Random Effects									
σ^2	0.20			0.20			0.20		
τ_{00}	0.11 $_{id}$			0.11 $_{id}$			0.10 $_{id}$		
ICC	.34			.36			.34		
Model Fit									
Marginal R^2	0.000			0.014			0.053		
Conditional R^2	0.340			0.371			0.370		
AIC	314.13			316.97			333.04		
BIC	323.84			329.92			355.70		
χ^2				0.00			0.00		

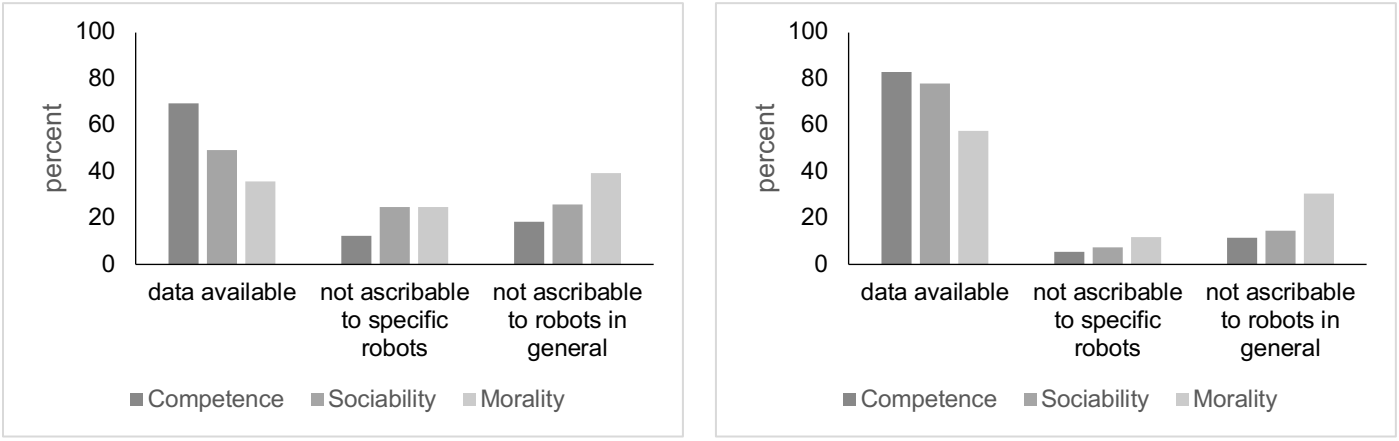
Note. N = 123, Observations = 188; GOT = Grade of Technicity.

*p <.05. **p < .01.

We furthermore investigated whether uniquely humane adjectives can be used to describe robots with varying levels of Anthropomorphism (RQ5). To account for participants' unwillingness to ascribe certain adjectives to robots, we included two possible answers: 'does not apply to this specific robot' and 'does not apply to robots in general' (Chita-Tegmark et al., 2021). Hence, we were able to further evaluate which adjectives specifically cause problems when ascribed to robots (Figure 2).

Figure 2

Distribution of answering options for robots for Social Perceptions



Note. Distribution of which percentage of participants agreed that Competence, Sociability, or Morality can be ascribed to robots in Study 1 (A) and Study 2 (B). χ^2 was computed to evaluate differences between attributions for the three types of answering options: participants could ascribe social dimensions to robots (data available), they could ascribe social dimensions to specific types of robots, e.g., social robots but not to other types of robots (not ascribable to specific robots), or they chose that these ascriptions are not applicable to any type of robot (not ascribable to robots in general).

We found significant differences in the ascription of attributions to robots, $\chi^2 = 11.08$, $df = 2$, $p = 0.004$, no differences in the willingness of attributions to certain robots, $\chi^2 = 5.08$, $df = 2$, $p = 0.079$, and significant differences in the ascription of attributions to robots in general, $\chi^2 = 8.19$, $df = 2$, $p = 0.017$, for the three dimensions of interest. Out of 459 participants, only 22 attributed adjectives of the Morality dimension to the industrial robot, 66 to the social robot, and 100 to the android robot. In terms of Sociability, 41 participants attributed adjectives to the industrial robot, 263 to the social robot, and 304 to the android robot. For Competence, the differences were not as large: 324 participants attributed Competence to the industrial robot, 355 to the social robot, and 347 to the android robot.

Findings on Social Perception of Embodied Digital Technologies

Our aim was to replicate prior findings on how technicality influences the perception of people with disabilities, and to extend it to the perception of different kinds of robots. We gained insight into how non-human beings such as industrial or social robots are perceived in terms of Competence, Sociability, and Morality compared to human beings. We evaluated general attributions on the aforementioned social dimensions and investigated possible interactions of inter-individual differences on these attributions.

Users of low-tech prostheses were seen as less competent than those of high-tech prostheses. This is in line with our Hypothesis 1 (but see Meyer & Asbrock, 2018). Perceived Sociability was independent of Restored Functionality. This is surprising since ratings of Warmth, which are higher for people with disabilities, were subsumed under the umbrella of Sociability. We find this interesting since perceived Morality was higher for people with disabilities, regardless of whether they used low- or high-tech prostheses. Industrial robots were perceived as more competent than more anthropomorphized robots. Industrial robots were

furthermore ascribed less Sociability than more anthropomorphized robots. Morality did not differ for types of robots. In general, individuals were reluctant to attribute inherently human characteristics such as Morality and, to some extent, Sociability to robots. We found small correlations between attributions of Competence, Sociability, and Morality and Emotionality, Empathic Concern, Perspective Taking, and Internalization for human beings. Personality variables were not correlated with attributions of the aforementioned social dimensions to robots. We will discuss those aspects together with the findings from study 2 in the General Discussion.

Introduction to Legal Perception of Embodied Digital Technologies

For study 2, we chose an interdisciplinary approach. We aimed at replicating the findings for robots of study 1. Additionally, we examined perceptions concerning legal aspects which have to be considered if robots shall become members of Hybrid Societies. This issue has been recognized by European institutions. They extensively discussed the question of how the EU and its member states could deal with this development. They discussed to establish an electronic person status and to define specific rights and obligations which should be granted to, or imposed on, robots. This is especially necessary because, with the growing autonomy of robots, they need to be seen less as tools than as agents (Resolution of the European Parliament, 2017/C 252/25). The connections that need to be established to identify a responsible party in case of error are often unclear and current existing concepts are no longer sufficient (Laukyte, 2019). Law in general, or legal institutions specifically, are challenged in a new way by advanced technologies (Calo, 2015). To address this development, two major dimensions of Legal Perception need to be considered: Legal Personality and subsequent Decision-Making Authority.

Dimensions of Legal Perception: Legal Personality

Legal Personality is a mandatory condition if robots are to become part of society. The term describes legal capacity. Legal capacity is the ability to be the bearer of rights and obligations. The law takes a person's Legal Personality and legal capacity for granted. Hence for now, Legal Personality is restricted to human actors. An extension to robots is discussed controversially. At present, robots arguably do not possess the capacities and attributions necessary to be considered as full moral or legal persons (Darling, 2012). There is a major reason why legal scholars are discussing whether robots should have rights, and why legislators need to consider this question. That is that a responsibility gap emerges when autonomous, intelligent robots act erroneously. Suppose a robot is no longer regarded as a machine or tool, which is already rejected in principle in some respects (Bryson, 2010; Bertolini, 2013), its situation can be compared to that of a substitute (Gutmann et al., 2012). In a comparable civil law constellation between human actors, the gap in responsibility of the legally represented person is bridged by the acting person. This is currently inconceivable in the case of robots. If at all, they should only be regarded as having partial legal capacity. This means that they could only be legally capable insofar as this is necessary for the applicability of the attribution rules of agency law and contractual liability for damages (Riehm, 2020). For this reason, the category of the e-person is discussed, which could be placed next to the natural and legal person. A distinction has to be made between Legal Personality and legal capacity. The e-person as a digital legal entity could participate in a legal transaction, have their assets, and be the addressee of legal obligations. Due to their legal capacity, an e-person would be able to be the bearer of rights and obligations under civil law. In addition, they would be capable of exercising fundamental rights from a constitutional perspective, and be capable of committing criminal acts (Robotics Open Letter, 2021). In

principle, legal capacity is based on the assumption that personal status is reserved for natural persons. This raises another problem: the legal capacity of legal persons in the German legal sphere is based on the fact that a natural person is ultimately in charge (Riehm, 2020). This is different from Anglo-American law, where legal capacity is necessary for a company to sue and be sued. The addressee here is the company itself. (Kraakman et al., 2017; Watson, 2018). This is why a uniform assessment of this question poses problems when it comes to justification. There is major disagreement on the topic of robot rights. Some researchers agree that as long as a robot possesses several essential characteristics describing the ability to have rights, such as consciousness, intentionality, rationality, personality, autonomy, or sentience, they should be granted these rights (Coeckelbergh, 2010; Sparrow, 2011; Gunkel, 2018; Tavani, 2018). A contrary argument is that the granting of (fundamental) rights stands in contradiction to the Charter of Fundamental Rights in particular (Robotics Open Letter, 2021). Furthermore, the capacity to act in the legal sense is mandatory. This necessarily requires corporeality, but it is unclear at what level of autonomy sufficient Legal Personality is achieved (Riehm, 2020). Bryson (2010) finds very drastic words for this dilemma: “Robots should be slaves [. . .] or servants [because] [. . .] we design, manufacture, own, and operate robots” (p. 3). Bertolini (2013) argues that robots cannot be recognized as legal subjects because they are not autonomous beings. The idea that robots should have rights is therefore inconceivable (Levy, 2005).

Dimensions of Legal Perception: Decision-Making Authority

Decision-Making Authority serves as the precondition for the capacity to act. This is defined as the ability to understand the significance and consequences of a person’s actions in the relevant context, to determine his or her will accordingly, and to act correspondingly. This capacity is

presumed in the case of persons of full age. This also necessarily presupposes that this person has a Legal Personality. Decision-Making Authority includes the ability to discern between options, that is, to decide, for example, whether an action is wrong or right. It can be seen as a necessary requirement for the status of a Legal Personality.

Legal Perception and Anthropomorphism

So far, discussions on the topic of robot rights have focused on the question of whether robots should have rights in a moral, and a next step in a legal sense. This poses questions of who will be granted which rights under which conditions and how these rights will be imposed. The question of who is primarily focusing on the type of robot. In many cases, literature explicitly deals with 'social robots' (Tavani, 2018). This category was defined as physically embodied agents which communicate and interact with humans on a social level (Darling, 2012, 2016). By employing this definition, industrial and service robots, as well as softbots (e.g., software), are excluded. Here, too, the major effect of Anthropomorphism needs to be considered. Due to physicality, perceived autonomous movement, and social behavior, these robots are viewed as potential social interaction partners. They are therefore more likely to have rights attributed to them (Darling, 2012; Turkle, 2012). Nevertheless, the legal system does not allow for this differentiated view. Whether or not robots should have rights invites discussions about necessary preconditions. Central questions are 1) can robots have rights, concerned with the question of capabilities of the robots, and 2) should robots have rights, concerned with the question of obligations towards the entity (Gunkel, 2018). By following this idea, it becomes apparent that as soon as the capabilities can be affirmed, the question of ought would also have to be answered positively. Only after theoretically affirming the attribution of any rights, the question of how needs to be considered. In particular, this poses the problem of how we, as human beings, can

know whether a robot should be able to prove that it has the necessary characteristics to be granted rights. Gunkel (2018) describes that proof can only be granted by violating the potential rights of the robot.

To replicate the findings of study 1 on Social Perception of robots in terms of the extended Stereotype Content Model (Fiske et al., 2002; Kervyn et al., 2015), we posed the following Research Question RQ6[4]: How are robots with different levels of Anthropomorphism are perceived in terms of 1) Competence, 2) Sociability, and 3) Morality?

We furthermore evaluated whether personality variables were associated with the attributions of 1) Competence, 2) Sociability, and 3) Morality to robots with different levels of Anthropomorphism (RQ7). Additionally, we investigated whether uniquely humane adjectives could be used to describe robots with varying levels of Anthropomorphism (RQ8).

To widen the scope to legal attributions to robots, we hypothesized that:

H2: With higher levels of Anthropomorphism, legal Decision-Making Authority is more likely ascribed to robots.

H3: With higher levels of Anthropomorphism, robots are more likely to be perceived as Legal Personalities.

We furthermore evaluated whether there is an association between the ascription of Decision-Making Authority and between the perception as a (Legal) Personality, and Social Perceptions (operationalized as Competence, Sociability, and Morality; RQ9).

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[4] We decided to consecutively number Research Questions and Hypotheses for Study 1 and Study 2.

Study 2: Social and Legal Perception of Embodied Digital Technologies

Prior to data collection, the present study was preregistered on OSF (https://osf.io/xevkp). The procedure was evaluated and approved by the Ethics Committee. It was not considered to require further ethical approvals and hence, as uncritical concerning ethical aspects according to the criteria used by the Ethics Committee which includes aspects of the sample of healthy adults, voluntary attendance, noninvasive measures, no deception, and appropriate physical and mental demands on the subject.

Methods

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study (Simmons et al., 2012).

Participants. We conducted an a-priori-power analysis with G*Power (version 3.1.9.6; Faul et al., 2007) for a one-way ANOVA with fixed effects. A medium effect size of 0.25 was assumed and power set to 0.95, resulting in a sample size of $n = 462$. The sample was acquired via clickworker GmbH (www.clickworker.de), an online survey platform. We decided to switch to clickworker GmbH from Prolific Academic since the relevant subsample was exhausted. We conducted a pilot study ($n = 30$) to assess the mean processing time. By including a manipulation check, we were able to exclude participants who did not read the instructions carefully and of whom we would expect their data to be flawed. 29 participants did not meet the requirements of the manipulation checks and were therefore excluded, leaving the final sample size at $n = 433$. We checked for outliers that were specified at having rated the social dimensions outside of ± three standard deviations from the mean and ran analyses twice: once by including and once by excluding the outliers. The results did not differ from each other, which is why for further analyses, all participants were considered. The mean age of the sample was $M = 39.68$ ($SD =$

12.37). The sample consisted of 150 female, 280 male, and three non-binary participants. The sample was mostly highly-educated, with 44.34% having obtained a university degree (high-school diploma: 27.25%, other degrees: 28.41%). Countries of residence of the participants were Germany (92.84%), Austria (5.77%), and Switzerland (1.39%).

Measures.

Stimulus Material. The stimulus material consisted of three pictures of robots with varying levels of Anthropomorphism: an industrial robot, shown in a laboratory setting, a social robot (Pepper, SoftBank Robotic Europe), and an android (Arlamovsky, 2019), both of which were shown in a neutral setting. The pictures of the robots were identical to the ones used in study 1. To assess Competence, Sociability, and Morality, all pictures were presented in random order with instructions to rate how the participants perceive the robot, how they think the robot would act/think/react, even though this first impression might be wrong and revoked later. 25 adjectives on opposing ends of a semantic differential were presented in random order, to be rated on a five-point Likert scale. Analogously to study 1, two additional choices were given for Competence, Sociability, and Morality, in accordance with Chita-Tegmark et al. (2021): 'does not apply to robots in general' and 'does not apply to this specific robot'. We presented seven items concerned with Legal Personality and twelve items concerned with Decision-Making Authority to assess Legal Perception. Participants were instructed to rate on a five-point Likert scale to which extend they agreed or disagreed with each statement (for full material see Supplementary C).

Items. We composed the itemset to cover the four main dimensions of Social Perception (Competence, Sociability, Morality, and Anthropomorphism, see study 1) and two additional dimensions of Legal Perception (Decision-Making Authority and Legal Personality).

Competence, Sociability, Morality, and Anthropomorphism were captured in the same way as in study 1 (see study 1, Items). Adjectives were presented as a semantic differential to be rated on a five-point Likert scale. We ran reliability analyses for all scales (McDonald's $Omega_{Competence}$ = .56, McDonald's $Omega_{Sociability}$ = .63, McDonald's $Omega_{Morality}$ = .67, McDonald's $Omega_{Anthropomorphism}$ = .58). We assessed personality variables by employing identical questionnaires as in study 1 and ran subsequent reliability analyses for this sample (Table 1).

Legal Personality: Seven items were derived from the co-authors' legal expertise to assess the agreement of participants on whether a robot was seen as being able to hold Legal Personality (for full material see Supplementary C). We chose items that reflect facets of what would be (un-)typical for natural persons (e.g., *This robot is a tool*). These items were rated on a five-point Likert scale ranging from 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, *5 = strongly agree*. Due to technical issues, one item (*This robot is an electronic person*) had to be excluded from all further analyses (McDonald's Omega = .49).

Decision-Making Authority: Twelve items were derived from the co-authors' legal expertise to evaluate whether participants would agree that robots are able to make a decision with regard to a pair of adjectives, for example, *This robot can distinguish between 'white and 'black'*. These items were rated on a five-point Likert scale ranging from *1 = strongly disagree*, *2 = disagree*, *3 = neutral*, *4 = agree*, *5 = strongly agree*. All evaluated terms have legal implications: To assess indeterminate legal concepts such as fault due to gross or ordinary negligence, immorality, or good faith, these abilities must be present in a person (McDonald's Omega = .88).

Procedure. The study was conducted as an online survey. Analogously to study 1, participants first gave informed consent and filled in a sociodemographic questionnaire. Next,

three pictures were presented, which were rated on a total of 25 adjectives that comprised the six scales of Social Perception. To evaluate perceived Decision-Making Authority and Legal Personality, we presented the same pictures of the robots. Participants had to decided to which extend they agreed or disagreed with the statements presented. Afterward, participants completed six questionnaires to assess personality variables. Upon finishing, participants received a code to receive a compensation of EUR 3.60. The total processing time was approximately 20 min. Additional questions concerned with the future perception of robots and their possible financial and legal responsibility were gathered for exploratory reasons and will not be reported here.

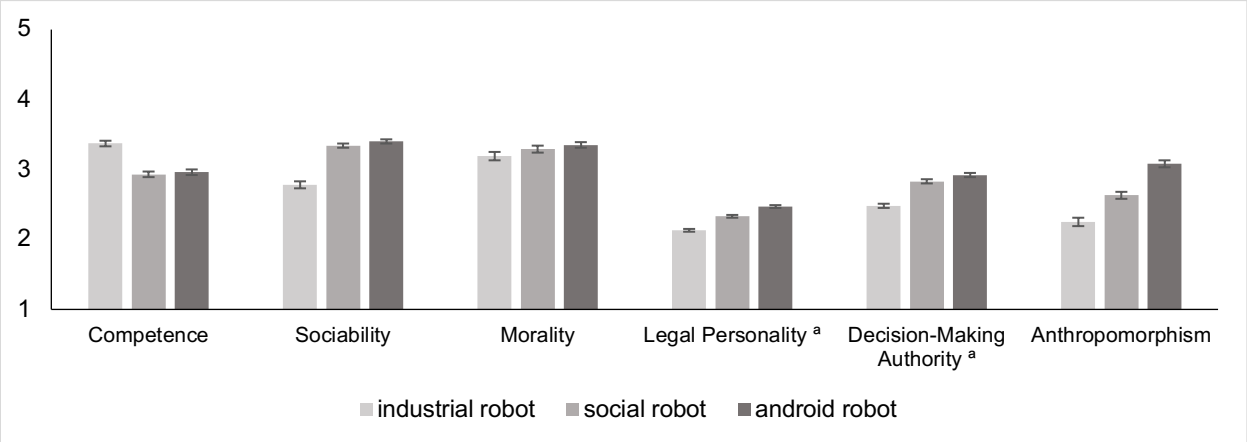
Statistical Analysis. All participants rated all of the three pictures. These three repeated measurements of the dependent variables were thus nested in participants; this was the case for Competence (ICC(1) = .29, $F_{(399, 671)} = 2.1$, $p < .001$, ICC(2) = .53), Sociability (ICC(1) = .18, $F_{(338, 398)} = 1.49$, $p < .001$, ICC(2) = .33), Morality (ICC(1) = .57, $F_{(176, 192)} = 3.72$, $p < .001$, ICC(2) = .73), Anthropomorphism (ICC(1) = .25, $F_{(297, 316)} = 1.68$, $p < .001$, ICC(2) = .41), Decision-Making Authority (ICC(1) = .54, $F_{(432, 866)} = 4.57$, $p < .001$, ICC(2) = .78), and Legal Personality (ICC(1) = .53, $F_{(432, 866)} = 4.42$, $p < .001$, ICC(2) = .77). We thus employed mixed models to account for nested data. We used R (Version 4.1.1; R Core Team, 2021) and the Rpackages dplyr (Version 1.0.7), tidyverse (Version 1.3.1), tidyr (Version 1.1.3), forcats (Version 0.5.1) for data management, psych (Version 2.1.6), sjstats (Version 0.18.1), ggpubr (Version 0.4.0), sjplot (Version 2.8.9), lm. beta (Version 1.5–1), apaTables (Version 2.0.8), and ggplot2 (Version 3.3.5) for descriptive analyses, MuMln (Version 1.43.17), effects (Version 4.2–0), emmeans (Version 1.6.2.1), mulitlevel (Version 2.6), stats (Version 4.0.2), lme4 (Version 1.1–27.1), pbkrtest (Version 0.5.1) and lattice (Version 0.20–44) for fitting Mixed Models and subsequent post-hoc testing.

Results

We fitted three Mixed Models with random intercepts for the variables Competence, Sociability, and Morality across the different types of stimuli (Figure 3). In all models, we controlled for participants' age, gender, and education. Personality variables, that is, personality dimensions of the HEXACO model, Need for Cognition, Affinity for Technology Interaction, Injustice Sensitivity, Moral Identity, and Empathy, with perceptions of Competence, Sociability, and Morality for both subgroups were correlated and adjusted for multiple comparisons (Holm, 1979). Furthermore, we fitted two Mixed Models with random intercepts for the variables Legal Personality and Decision-Making Authority across the three types of stimuli (Figure 3). Participants were less willing to attribute perceived Morality and Sociability to robots, independently of their anthropomorphic appearance. Competence was attributed more readily.

Figure 3

Estimated Marginal Mean Scores for Grades of Technicity and Social and Legal Perception



Note. $N = 433$; Competence: $n_{\text{industrial robot}} = 351$; $n_{\text{social robot}} = 362$; $n_{\text{android robot}} = 358$; Sociability: $n_{\text{industrial robot}} = 131$; $n_{\text{social robot}} = 291$; $n_{\text{android robot}} = 315$; Morality: $n_{\text{industrial robot}} = 71$; $n_{\text{social robot}} = 140$; $n_{\text{android robot}} = 158$; Anthropomorphism: $n_{\text{industrial robot}} = 163$; $n_{\text{social robot}} = 214$; $n_{\text{android robot}} = 237$. Error bars represent the Standard Error.

[a] Answering options range from *1 = strongly disagree* to *5 = strongly agree.*

Research Question 6 proposes that robots with different anthropomorphic appearances are associated with different perceptions of Competence, Sociability, and Morality. As for study 1, we first evaluated Anthropomorphism to find out the three robots of the stimulus material were indeed perceived as having different levels of Anthropomorphism. We regressed Anthropomorphism on type of robot with a corresponding Mixed Model. Indeed, type of robot was positively associated with perceived Anthropomorphism, $b = 0.41$, $SE = 0.03$, $t = 12.26$. Post-hoc Tukey tests showed that, in accordance with theoretical considerations, the industrial robot was perceived as less anthropomorphic than both the social robot, $\Delta M = 0.38$, $SE = 0.07$, $t = -5.43$, $p < 0.001$, and the android robot, $\Delta M = 0.82$, $SE = 0.07$, $t = -12.05$, $p < .001$. The android robot was perceived as more anthropomorphic than the social robot, $\Delta M = 0.45$, $SE = 0.06$, $t = -7.20$, $p < .001$ (Figure 3).

We subsequently ran three Mixed Models regressing attributions of Competence, Sociability, and Morality on type of robot.

The type of robot was associated with attributions of Competence (Table 8). Post-hoc Tukey tests showed that the industrial robot was perceived as more competent than both the social robot, $\Delta M = 0.44$, $SE = 0.05$, $t = 8.88$, $p < .001$, and the android robot, $\Delta M = 0.41$, $SE = 0.05$, $t = 8.28$, $p < .001$. Perceived Competence of the social robot and the android robot did not differ significantly, $\Delta M = 0.03$, $SE = 0.05$, $t = -0.58$, $p = .830$.

Table 8

Comparison of Fit Indices for Linear Mixed Models regressing Competence on Grade of Technicity.

Predictors	Model 0			Model 1			Model 2			Model 3		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
(Intercept)	3.09	0.03	<.001**	4.11	0.13	<.001**	4.11	0.14	<.001**	4.58	0.23	<.001**
GOT				-0.20	0.03	<.001**	-0.20	0.03	<.001**	-0.20	0.03	<.001**
Gender										-0.24	0.06	<.001**
Education										-0.00	0.00	.207
Age										0.01	0.03	.741
Random Effects												
σ^2	0.48			0.44			0.35			0.35		
τ_{00}	0.19 $_{id}$			0.21 $_{id}$			2.71 $_{id}$			2.64 $_{id}$		
τ_{11}							0.09 $_{id.got}$			0.09 $_{id.got}$		
ρ_{01}							-0.96 $_{id}$			-0.96 $_{id}$		
ICC	.29			.32			.45			.44		
Model fit												
Marginal R^2	0.000			0.041			0.041			0.064		
Condi-tional R^2	0.286			0.345			0.477			0.477		
AIC	2555.9			2501.3			2491.1			2499.7		
BIC	2570.9			2521.2			2520.9			2544.4		
χ^2				56.67**			14.21**			0.00		

Note. N = 400, Observations = 1071; GOT = Grade of Technicity.

*p <.05. **p < .01.

The type of robot was furthermore positively associated with perceived Sociability (Table 9). Post-hoc Tukey tests showed that the industrial robot was attributed less Sociability than the social robot, $\Delta M = 0.56$, $SE = 0.06$, $t = -10.00$, $p < .001$, and the android robot, $\Delta M = 0.63$, $SE = 0.06$, $t = -11.23$, $p < .001$. Perceived Sociability of the social and android robot did not differ significantly, $\Delta M = 0.06$, $SE = 0.04$, $t = -1.49$, $p = .300$.

Table 9

Comparison of Fit Indices for Linear Mixed Models regressing Sociability on Grade of Technicity

Predictors	Model 0			Model 1			Model 2		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
(Intercept)	3.28	0.03	<.001**	1.89	0.15	<.001**	2.24	0.22	<.001**
GOT				0.26	0.03	<.001**	0.26	0.03	<.001**
Gender							-0.11	0.05	.034*
Education							-0.02	0.02	.413
Age							-0.00	0.00	.415
Random Effects									
σ^2	0.33			0.28			0.28		
τ_{00}	0.08 $_{id}$			0.09 $_{id}$			0.09 $_{id}$		
ICC	.20			.25			.24		
Model Fit									
Marginal R^2	0.000			0.091			0.100		
Conditional R^2	0.202			0.314			0.320		
AIC	1429.0			1351.1			1371.6		
BIC	1442.8			1369.5			1403.8		
χ^2				79.95**			0.00		

Note. N = 339, Observations = 737; GOT = Grade of Technicity.

*p <.05. **p < .01.

The type of robot was not associated with perceived Morality (Table 10). Research Question 7 was concerned with associations between personality variables and attributions of Competence, Sociability, and Morality to robots. Correlational analyses revealed small to moderate positive correlations between Internalization and attributions of Competence (r = .28),

and Sociability (r = .38). Conscientiousness showed a moderate correlation with attributions of Competence (r = .31). Attributed Sociability showed moderate positive correlations with Affinity for Technology Interaction (r = .35), Need for Cognition (r = .33), and Honesty-Humility (r = 0.36) (Supplementary D).

Table 10

Comparison of Fit Indices for Linear Mixed Models regressing Morality on Grade of Technicity.

Predictors	Model 0			Model 1			Model 2		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
(Intercept)	3.30	0.04	<.001**	2.89	0.16	<.001**	2.95	0.31	<.001**
GOT				0.08	0.03	.007**	0.08	0.03	.008**
Gender							0.06	0.08	.423
Education							-0.05	0.03	.091
Age							0.00	0.00	.417
Random Effects									
σ^2	0.15			0.14			0.14		
τ_{00}	0.19 $_{id}$			0.19 $_{id}$			0.18 $_{id}$		
ICC	.57			.57			.56		
Model Fit									
Marginal R^2	0.000			0.010			0.030		
Conditional R^2	0.568			0.572			0.576		
AIC	571.08			571.24			590.33		
BIC	582.81			586.88			617.71		
χ^2				1.84			0.00		

Note. N = 177, Observations = 369; GOT = Grade of Technicity.

*p <.05. **p < .01.

Research Question 8 was concerned with evaluating whether uniquely humane adjectives can be used to describe robots with varying levels of Anthropomorphism. To account for participants' inability to ascribe certain adjectives to robots, we included two possible answers: 'does not apply to this specific robot' and 'does not apply to robots in general' (Chita-Tegmark et al., 2021). Hence, we were able to further evaluate which adjectives specifically cause problems when ascribed to robots (Figure 2).

We found no differences in the ascription of attributions to robots, $\chi^2 = 5.00$, $df = 2$, $p = .080$, no differences between the dimensions to ascribe attributions to certain robots, $\chi^2 = 2.54$, $df = 2$, $p = .280$, and significant differences in the ascription of attributions to robots in general, $\chi^2 = 11.2$, $df = 2$, $p = .004$, for the three dimensions of interest. Analogously to study 1, attributions of humane adjectives, that is, terms that described Sociability or Morality, were not readily applied to robots, whereas adjectives that described Competence were attributed to robots. Out of 433 participants, only 71 attributed adjectives of the Morality-dimension to the industrial robot, 140 to the social robot, and 158 to the android robot. In terms of Sociability, 131 participants attributed adjectives to the industrial robot, 291 to the social robot, and 315 to the android robot. For Competence, the differences were not as big: 351 participants attributed Competence to the industrial robot, 362 to the social robot, and 358 to the android robot.

Hypothesis 2 predicted that more Decision-Making Authority is ascribed to robots with higher-level Anthropomorphism. To test for this hypothesis, we ran a Mixed Model regressing Decision-Making Authority on the Grade of Technicity. Indeed, the type of robot was associated with Decision-Making Authority (Table 11). In general, participants were cautious to neutral to agree that robots could have Decision-Making Authority, which limitates the interpretability of the findings. Post-hoc Tukey tests revealed that the android robot was perceived as having more

Decision-Making Authority than the industrial robot, $\Delta M = 0.44$, $SE = 0.03$, $t = -14.54$, $p < .001$, and the social robot, $\Delta M = 0.09$, $SE = 0.03$, $t = -2.88$, $p = .010$. The social robot was ascribed more Decision-Making Authority than the industrial robot, $\Delta M = 0.36$, $SE = 0.03$, $t = -11.66$, $p < .001$.

Table 11

Comparison of Fit Indices for Linear Mixed Models regressing Decision-Making Authority on Grade of Technicity.

Predictors	Model 0			Model 1			Model 2		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
(Intercept)	2.74	0.03	<.001**	1.63	0.08	<.001**	2.00	0.21	<.001**
GOT				0.22	0.02	<.001**	0.22	0.02	<.001**
Gender							-0.11	0.06	.061
Education							-0.01	0.03	.711
Age							-0.00	0.00	.171
Random Effects									
σ^2	0.26			0.21			0.21		
τ_{00}	0.30 $_{id}$			0.32 $_{id}$			0.32 $_{id}$		
ICC	.54			.61			.61		
Model Fit									
Marginal R^2	0.000			0.058			0.067		
Conditional R^2	0.544			0.631			0.633		
AIC	2583.4			2407.2			2427.1		
BIC	2598.9			2427.9			2463.2		
χ^2				178.17**			0.00		

Note. $N = 433$, Observations = 1299; GOT = Grade of Technicity.

*p <.05. **p < .01.

Hypothesis 3 predicted that more anthropomorphized robots are ascribed more Legal Personality. The type of robot was associated with ascriptions of Legal Personality (Table 12).

Table 12

Comparison of Fit Indices for Linear Mixed Models regressing Legal Personality on Grade of Technicity.

Predictors	Model 0			Model 1			Model 2		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
(Intercept)	2.31	0.02	<.001**	1.47	0.06	<.001**	1.60	0.15	<.001**
GOT				0.17	0.01	<.001**	0.17	0.01	<.001**
Gender							0.03	0.04	.528
Education							-0.01	0.02	.436
Age							-0.00	0.00	.145
Random Effects									
σ^2	0.13			0.11			0.11		
τ_{00}	0.15 $_{id}$			0.16 $_{id}$			0.16 $_{id}$		
ICC	.53			.60			.60		
Model Fit									
Marginal R^2	0.000			0.065			0.070		
Conditional R^2	0.533			0.631			0.633		
AIC	1731.2			1536.2			1560.7		
BIC	1746.8			1556.9			1596.9		
χ^2				196.99**			0.00		

Note. N = 433, Observations = 1299; GOT = Grade of Technicity.

*p <.05. **p < .01.

As with Decision-Making Authority, participants were reluctant to agree that robots in general could have Legal Personality. Post-hoc Tukey tests showed that the android robot was perceived as having more Legal Personality than the social robot, $\Delta M = 0.14$, $SE = 0.02$, $t = -6.15$, $p < 0.001$, and the industrial robot, $\Delta M = 0.34$, $SE = 0.02$, $t = -15.18$, $p < 0.001$. The social robot was ascribed more Legal Personality than the industrial robot, $\Delta M = 0.20$, $SE = 0.02$, $t = -9.04$, $p < 0.001$. With regard to Research Question 9, we evaluated possible associations between Social and Legal Perceptions using a correlational design with adjustment for multiple comparisons (Holm, 1979). We found strong correlations between the three social dimensions Competence and Sociability ($r = 0.51$), Competence and Morality ($r = 0.60$), and Sociability and Morality ($r = 0.74$). Decision-Making Authority showed a moderate positive correlation with Legal Personality ($r = 0.48$) and small to moderate positive correlations with Competence ($r = 0.21$), Sociability ($r = 0.33$), and Morality ($r = 0.43$).

Findings on Social and Legal Perception of Embodied Digital Technologies

In study 2, we investigated how robots of varying levels of Anthropomorphism are perceived in terms of social and legal dimensions. These dimensions were Competence, Sociability, Morality, Decision-Making Authority, and Legal Personality. Furthermore, we investigated whether interindividual differences would be associated with perceptions of these social dimensions. Ascriptions of Competence and Sociability were in line with the results from study 1. The results indicated that industrial robots are seen as more competent but less sociable than more anthropomorphized robots. In contrast to study 1, more Morality was ascribed to the android robot than to the industrial robot. This can be cautiously interpreted as that a higher level of Anthropomorphism facilitates ascriptions of uniquely humane attributions. Still, only a minority of participants were willing to ascribe adjectives of the dimension of Morality to industrial

robots. Even for the most anthropomorphized robot, the android, not even half of the participants did so. Therefore, we suggest that, analogously to study 1, attributions of Morality to robots were problematic to say at least. We found moderate positive correlations between Internalization and attributions of Competence and Sociability. Conscientiousness showed a moderate correlation with attributions of Competence. Attributed Sociability showed moderate positive correlations with Affinity for Technology Interaction, Need for Cognition, and Honesty-Humility.

Hypothesis 2 predicted that more anthropomorphized robots are attributed more Decision-Making Authority. This was supported by our data with the limitation that participants were reluctant to attribute Decision-Making Authority to robots in general. The more anthropomorphized robots, that is, the social robot and android robot, were attributed more Decision-Making Authority than the industrial robot. Hypothesis 3 predicted that more anthropomorphized robots are attributed more Legal Personality. Our results supported Hypothesis 3 with the same restriction: participants were reluctant to attribute Legal Personality to robots in general.

Legal Personality was not associated with Social Perceptions, but Decision-Making Authority was: Perceptions of Competence, Sociability, or Morality were associated with Decision-Making Authority. This can be interpreted in such a way that both constructs need to be considered in close proximity and might stem from a common background.

General Discussion

We conducted two studies, aiming at a more thorough understanding of how individuals with disabilities using low- and high-tech prostheses, and robots are perceived in terms of social and legal dimensions. In study 1, we aimed at replicating prior findings of changes in Social Perception if bionic prostheses are used by people with physical disabilities (Meyer & Asbrock,

2018). Furthermore, we widened the scope in two directions. We divided the social dimension of Warmth into Sociability and Morality, and we extended the focus to robots of varying levels of Anthropomorphism. Attributions of Social Perception to robots showed mixed results. Participants attributed Competence and, partly, Sociability, to robots. Conversely, participants were not willing to attribute Morality to robots, independently of the robots' anthropomorphic level.

Study 2 aimed at replicating the findings of study 1 for robots and extended the perception by a legal component. We could mostly replicate the findings of study 1. Legal Perception, that is, Legal Personality and Decision-Making Authority, were partly associated with anthropomorphic appearance.

Social Perception of Human Beings with Protheses

We hypothesized that users of bionic prostheses would be attributed more perceived Competence than users of low-tech prostheses. Furthermore, we investigated whether there are associations between the technicity of prostheses and attributions of Social Perception, that is, Sociability and Morality.

Restored Functionality was a better predictor of perceptions of Competence, Sociability, and Morality than Grade of Technicity. Users of bionic prostheses were perceived as more competent than users of low-tech prostheses. At the same time, they were ascribed more Morality than able-bodied individuals. This indicates that their disability still affected Social Perception (Meyer & Asbrock, 2018). Perception of Sociability was not associated with types of prostheses. This lends weight to the approach of the division of the Stereotype Content Model dimension Warmth into Morality and Sociability (Leach et al., 2007; Heflick et al., 2011; Kervyn

et al., 2015). Apparently, perceptions between these two dimensions differ, and by pooling them, explanatory value might be lost or at least reduced.

Social Perception of Robots

We investigated whether attributions of Competence, Sociability, and Morality were associated with levels of Anthropomorphism of robots. Furthermore, we investigated whether people were willing to ascribe these attributions to robots. The findings were predominantly in line with prior findings. The results indicated that effects of Anthropomorphism on Social Perceptions are present. The general public is still cautious of granting robots attributions in previously uniquely humane domains such as Sociability and Morality. This might be partly explained by the fact that the majority of people are not in direct contact with robots. Therefore, they might not be able or willing to assess robots in an unbiased way. As Naneva et al. (2020) pointed out, there is evidence that attitudes towards robots or cyborgs are currently based on fiction and threatening images (e.g., The Terminator; Cameron, 1984) rather than facts or objective reality, respectively. This assumption is also strengthened by recent research based on intergroup relations. Sarda Gou et al., 2021) showed that direct contact with robots positively affected participants' explicit and implicit attitudes toward robots. Direct contact might also be the crucial factor in why we found rather reserved attributions to robots while people working with robots attribute positive and negative human characteristics to them (Sauppé & Mutlu, 2015). Further studies should address whether differences in perception persist if people work with robots or not and whether perceptions in work settings can be conferred to social settings. We assume that attitudes towards and emotions evoked by robots will become more realistic and objective in the long run. Longitudinal studies should be conducted to assess and monitor those changes. In comparing study 1 and study 2, it is notable that the percentage of individuals who ascribed social

attributions to robots changed. Fewer people ascribed moral or sociable capacities to robots if they were shown in close succession with human beings rather than when the stimuli only contained robots. We suggest that this might be due to robots being perceived as the other (Gunkel, 2018), and therefore making ascriptions of social dimensions harder.

The Role of Individual Differences in Social Perception

Associations between personality variables and Social Perceptions remain inconclusive. In study 1, we found evidence that people with higher scores in Emotionality, Empathic Concern, Internalization and, in parts, Observer Sensitivity and Perpetrator Sensitivity, tended to attribute more Competence, Sociability, and Morality. This was independent from whether people wore prostheses of any type or not. Empathic Concern, as well as Observer Sensitivity and Perpetrator Sensitivity are moderately correlated, as is Emotionality with these three variables. This might point to a specific disposition of people being especially compassionate and empathetic. They might tend to ascribe more positive attributions to other people. Internalization, the degree to which a persons' private views are centered on moral traits (Aquino & Reed, 2002), might be interpreted in a similar direction. For robots, associations between personality variables and attributions of social dimensions differed between study 1 and 2. In study 1, no associations were found. We consider that by mixing human and robotic stimuli, we made the differences between the two subgroups more salient. Attributions were, therefore, more conservative. This was reflected in the low number of participants who decided to attribute Sociability or Morality to robots. In study 2, only robotic stimuli were presented. Slightly more participants attributed Competence, Sociability, and Morality to robots, even though we still interpret these results carefully. Higher Internalization, as was true for the human subgroup of study 1, was associated with higher overall attributions of Competence and Sociability. This could be interpreted in such

a way that this personality trait is important for any attribution really, independently from who or what it is attributed to. Attributions of Sociability were correlated with Affinity for Technology Interaction and Need for Cognition. Higher positive interest in technical gadgets and subsequently in the interaction with robots (de Graaf & Ben Allouch, 2013) leads to more attributions of human adjectives to robots. Furthermore, Need for Cognition is associated with the ability to access nonanthropomorphic representations more readily instead of relying on Anthropomorphism (Epley et al., 2007). To conclude, we found evidence that personality variables are associated with Social Perception, but, especially for the area of robots, further research is needed.

Legal Perception of Robots

Currently, discussion about granting robot rights, and the basis necessary for it, is conducted by experts from various fields, legislative institutions, and their advisors. Therefore, we investigated whether the participants associate typical legal attributions with the stimuli. We focused on two concepts: Legal Personality and Decision-Making Authority. We selected only these two legal concepts as they relate to natural persons. In the future, other categories may be added, such as the issue of tort capacity. To what extent robots may have human characteristics and to what extent they might also have legal capacity is currently the subject of a multi-layered debate. The discussion on rights for robots is focused on social robots, as by Tavani (2018) or Darling (2012, 2016). They only deal with the category of robots that communicate and interact on the social level. This definition of social robots as physically embodied agents that communicate and interact with humans on a social level (Darling, 2012, 2016) excludes industrial and service robots as well as softbots (e.g., software) from the grant of rights. The results of our study can be cautiously interpreted as partly supporting this assumption. Overall, participants were neutral to

dismissive to agree with the statements which indicated Decision-Making Authority for robots. Within this range, more anthropomorphic robots were attributed more Decision-Making Authority. Similar to what was described by Darling (2012) and Tavani (2018), there is a tendency that the more humanlike a robot looks and is perceivably programmed, the more they are seen as capable of making legally relevant decisions corresponding to humans. Therefore, they are seen as proficient in this respect. This might be caused by the fact that we, as humans, project our characteristics onto other human-like beings. Therefore, we feel more comfortable with granting them a certain legal standing. Nonetheless, further research is needed. If such a result is indeed confirmed on the long run, it would have meaningful implications for the use of robots. If the ascription of Decision-Making Authority is not in focus, anthropomorphic appearance is not necessary. But if this authority is of importance (e.g., in advertising), then the appearance should be considered. The same is true for the ascription of Legal Personality to robots. Participants were neutral to dismissive to agree that robots could possess Legal Personality. Within this range, more anthropomorphized robots were perceived as more eligible for Legal Personality.

Previous research agrees that once a robot has certain inherent abilities that are human-like, especially if they have some sort of consciousness, they should also be granted rights (Sparrow, 2004, 2011; Singer and Sagan, 2009; Coeckelbergh, 2010; Gunkel, 2018; Tavani, 2018). While Bryson, 2010) considers robots as tools, or the basic legal capacity is denied (Robotics Open Letter, 2021), a trend can be observed that this is confirmed with regard to industrial, but less so for social and android robots. From this, it can be deduced that in a further legal discussion about robot rights, the similarity to humans must be included. This has to be done at a more sophisticated level than has been the case to date to increase the acceptance of

new regulations. Keeping the aforementioned limitation in mind, these results indicate that there might be an association between levels of Anthropomorphism and acceptance of robots as members of a hybrid society in a legal sense. This applies to both appearance and the internal possibility of making decisions that ultimately have a legal effect. These aspects should be taken into account in the justification of new interpretations of norms.

Limitations

The present studies are not without limitations. For one, we evaluated the Social Perception of robots and individuals with and without physical disabilities with low- and high-tech prostheses in a relatively straightforward way by presenting unmoving pictures. Research has shown that the existence of movement plays a role in how robots are perceived (Kupferberg et al., 2011). This is why we see the present research as the first step towards a better understanding of the Social Perception of robots. We will take into the field as a subsequent next step. Pictures of individuals are highly influenced by personal taste. We decided on presenting pictures of actual human beings, so they differed in their physical appearance and might have influenced their perception. We refrained fromusing the RoSA Scale (Carpinella et al., 2017) to measure the Social Perception of robots and instead used scales from the Godspeed Inventory (Bartneck et al., 2009) and the Stereotype Content Model (Fiske, 2018; Meyer & Asbrock, 2018), since we not only investigated perceptions of robots but also of human beings. This decision comes with certain downfalls. The subscales Animacy and Anthropomorphism of the Godspeed Inventory (Bartneck et al., 2009) were shown to load on the same factor. Nevertheless, the core dimensions of Social Perception are unaffected by this decision (Scheunemann et al., 2020). Since we were dipping into a new field of research with employing legal questions in a survey setting, scales will need revision to provide a more conclusive insight. One should therefore interpret the results

on Legal Perception of robots cautiously. Furthermore, technical issues accounted for the loss of one item of the scale for Legal Personality, which had a detrimental effect on the interpretability.

Conclusions

The present study shows that perceptions of Competence and Morality of users of prostheses varies as a function of technical sophistication of the prostheses. Conversely, we did not find any differences in perceived Sociability. The Social Perception of robots is strongly dependent on the perceived Anthropomorphism of the specific robot. This is not to say that robots can be easily ascribed humane attributions. Some attributes, for example, in terms of Competence or Sociability, can be used to describe both humans and robots. For more abstract terms like moral perceptions, a difference is made between humans and robots. In general, the public is reluctant to see robots as personalities in a psychological and legal sense. Therefore, we infer that at the present time, robots are not perceived as equivalents to ‘co-workers’. This might change with greater availability of anthropomorphized robots. To sum it up, despite the downfalls, we can present new insights into a field which, in the future, will be of great importance for researchers and society alike.

Data Availability Statement

The original contributions presented in the study are included in the Supplementary Materials, further inquiries can be directed to the corresponding author

Ethics Statement

The studies involving human participants were reviewed and approved by Ethics Committee of the Faculty of Behavioral and Social Sciences of Chemnitz University of Technology. The participants provided their written informed consent to participate in this study.

Author Contributions

AS, FA, BM, SM, and MB had the original idea for the study, SM and MB collected and analyzed the data. SM wrote the majority of the manuscript. SMe and DG-N helped with developing hypotheses on legal issues. MB contributed to writing the introduction to Study 1 and the discussion. SMa contributed to writing the introduction to Study 2 and the discussion. AS, FA, BM, and DG-N provided comprehensive internal review.

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Supplementary Material

The Supplementary Material for this article can be found online at:

https://www.frontiersin.org/articles/10.3389/frobt.2022.787970/full

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Social perception of embodied digital technologies – a closer look at bionics and social robotics

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Abstract

This contribution of the journal Gruppe. Interaktion. Organisation. (GIO) presents a study on the social perception of Embodied Digital Technologies (EDTs) and provides initial insights into social perception processes concerning technicality and anthropomorphism of robots and users of prostheses. EDTs such as bionic technologies and robots are becoming increasingly common in workspaces and private lives, raising questions surrounding their perception and their acceptance. According to the Stereotype Content Model (SCM), social perception and stereotyping are based on two fundamental dimensions: Warmth (recently distinguished into Morality and Sociability) and Competence. We investigate how human actors, namely able-bodied individuals, users of low-tech prostheses and users of bionic prostheses, as well as artificial actors, such as industrial robots, social robots, and android robots, are perceived in terms of Competence, Sociability, and Morality. Results show that individuals with low-tech prostheses were perceived as competent as users of bionic prostheses, but only users of low-tech prostheses were perceived less competent than able-bodied individuals. Sociability did not differ between users of low-tech or bionic prostheses or able-bodied individuals. Perceived morality was higher for users of low-tech prostheses than users of bionic prostheses or able-bodied individuals. For robots, attributions of competence showed that industrial robots were perceived as more competent than more anthropomorphized robots. Sociability was attributed to robots to a lesser extent. Morality was not attributed to robots, regardless of their level of anthropomorphism.

Keywords: Embodied Digital Technologies, bionics, social robotics, social perception, stereotypes, anthropomorphism

Introduction

Modern societies are characterized by technological change and increasing use of Embodied Digital Technologies (EDTs), such as virtual reality devices, (social) robots, and bionic devices to reestablish or augment the capabilities of their users. A change towards Hybrid Societies, which are composed of human protagonists as well as users of EDTs, is ongoing. EDTs include bionic prostheses and robots, whose common ground is a high grade of technicity and their physical presence. Social perception influences social interactions (Cuddy et al., 2008), which shapes how societies are constructed and maintained. With regard to the increasing digitalization of society, aspects and consequences of social perception will not be limited to humans any more, but could soon include artificial agents. Mirroring this trend, the number of robots in work settings has dramatically increased over the last years (Statistisches Bundesamt, 2021). While this development is welcomed by some, low-skill workers have shown rather negative reactions to robots in workspaces since first implementations in the 1980s (Chao & Kozlowski, 1986). These perceptions have partly changed over the last decades, whereas criticism, particularly in service sectors, mostly concerns the decreased human contact and unnecessary deployment of new technologies (Savela et al., 2021). With regard to augmenting bionic devices like exoskeletons, Gilotta et al. (2019) pointed out that social aspects might negatively influence acceptability in such a way that wearing exoskeletons can lead to stigmatization in the workplace due to users' perceived dependency on the supportive device.

Consequently, one must ask what can be done to mitigate these adverse effects and ensure the utmost acceptance while simultaneously using the inherent potentials. Therefore, it is inevitable to understand user perceptions, corresponding attributions, and evoked feelings, especially when it comes to the acceptance of users of bionic devices and social robots on a

broader societal level. Notwithstanding, we must consider that nowadays, the majority of people have no direct contact with such devices, and their attitudes towards them might be formed based on fiction rather than fact (Sarda Gou et al., 2021). Accordingly, we aim at a deeper understanding of how the basic principles of social perception influence the formation of attitudes towards social robots and bionics users and whether or how social perception is influenced in turn by different grades of technicity.

Typically used as a theoretical basis for the research on social perception, the Stereotype Content Model (SCM; Fiske et al., 2002) proposes two fundamental dimensions, Warmth and Competence, across which different groups are perceived by others. Due to its two-dimensionality, the SCM has recently been subject to critique (Abele et al., 2021). A third factor, Morality, usually included in the Warmth-dimension (Fiske, 2018), has been brought up by either dividing Warmth into two dimensions of Sociability and Morality (Kervyn et al., 2015), or by introducing Morality as a third factor into the original SCM-model (Heflick et al., 2011; Leach et al., 2007). Especially with regard to aforementioned Hybrid Societies, the inclusion of Morality needs to be researched more thoroughly (Mandl et al., 2022a), since its importance on ethical and prosocial behavior is indisputable (Hannah et al., 2011).

Research has shown that people with physical disabilities are perceived differently, that is, warmer and less competent, than able-bodied individuals (e.g., Cuddy et al., 2007; Fiske et al., 2002; Meyer & Asbrock, 2018). Bionic prostheses, which are highly technical and therefore appear more artificial than their purely cosmetic counterparts diverge from this perception: people with disabilities who use bionic prostheses reclaim perceived Competence (Mandl et al., 2022a; Meyer & Asbrock, 2018) and retain perceived Warmth usually associated with physical disabilities (Meyer and Asbrock, 2018). If Sociability and Morality are introduced as social

dimensions instead of Warmth (Kervyn et al., 2015), attributions of Sociability did not differ depending on the grade of technicity, but Morality did (Mandl et al., 2022a). With regard to robots of various grades of technicity, prior research has shown that attributions of Competence were higher for robots with clear scopes of applications such as industrial robots than for robots with more diverse application scenarios. Attributions of Sociability and Morality were rather ambiguous and remain inconsistent (Mandl et al., 2022a).

To contribute to the existing research and shed light onto the question of how these new actors are perceived, we identified two major research questions:

(1) How are users of prostheses and (2) different robots perceived in terms of the three major dimensions of social perception: Competence, Sociability, and Morality?

Social Perception

Social perception and social evaluation are central aspect for social interactions. Gathering fast and distinctive information about others is of highest importance for interactions with others. In early work on social perception, Asch (1946) showed that certain attributes (Warmth) were more important for impression formation about others than other attributes. Various approaches to capture and describe the most important dimensions for social perception followed, mostly describing two (Abele & Wojciszke, 2007; Fiske et al., 2002) or three (Koch et al., 2016; Osgood et al., 1957; see Abele et al., 2021 for an extensive review and theoretical integration). For the present study, we employ a well-developed model of the core dimensions of social perception, namely the Stereotype Content Model (SCM; Fiske et al., 2002), which focusses on the social perception of others in terms of stereotype dimensions. It postulates that all group stereotypes and interpersonal impressions are formed on two fundamental dimensions of Warmth (warm to cold), which depicts an individuals' perceived intentions (good to bad) and

Competence, depicting the self-explanatory area between competence and incompetence, resulting in four possible clusters. Based on these clusters, the SCM and its extension, the Behaviors from Intergroup Affect and Stereotypes (BIAS) map (Cuddy et al., 2007), predict specific emotional and behavioral reactions, such as compassion and sympathy for individuals with perceived low Competence and high Warmth, or envy and jealousy for individuals perceived as highly competent and low in warmth. As shown by Mieczkowski et al. (2019), recent results indicate that participants impressions of robots' Warmth and Competence led to similar emotional reactions as they had to humans. Consequently, these results suggest the applicability of the SCM and BIAS map to robots as well as to different contexts and cultures.

Social perception of people wearing prosthesis

Previous research has shown that people with physical disabilities are perceived as low in Competence and high in Warmth, evoking pity and active facilitation as a behavioral correlate (Asbrock, 2010; Cuddy et al., 2007; Fiske 2018; Fiske et al., 2002; Meyer & Asbrock, 2018). Recently, Meyer and Asbrock (2018) investigated effects of high-tech prostheses, or bionic prostheses, in contrast to prostheses with a lower grade of technicity, on social perception. Bionic prostheses reestablished perceived Competence to a degree comparable with able-bodied people, whereas users of low-tech prostheses were perceived as less competent. Interestingly enough, perceived Warmth only dropped if bionic prostheses were not used to restore functionality, but to enhance functionality of able-bodied people. If these people got labeled as cyborgs, beings comprised of technical and organic parts, perceived Warmth dropped even lower and they were regarded as rather frightening (Meyer & Asbrock, 2018). Further research has shown that the use of high- and low-tech prostheses causes differences in attributed Competence and Morality, but not attributed Sociability (Mandl et al., 2022a).

Social perception of robots

Research on social perception has been focused on human actors, which needs to be reevaluated under the assumption that robots are being widely deployed in workspaces and private spaces (Carpinella et al., 2017; Scheunemann et al., 2020; Turja & Oksanen, 2019). Robots in workspaces can be seen as either machines, mere aids without social implications (Demir et al., 2019; Savela et al., 2018), or as a type of co-worker, which in turn act as social partners (Demir et al., 2019; Sauppé & Mutlu, 2015). Especially with the impending widespread use of robots in service sectors, social perception plays a crucial role in whether robots will be accepted (Savela et al., 2018; Wiese et al., 2021). Recently, the term moral machines has gained traction in Human-Roboter Interaction research, that is, the approach of implementing the ability of moral decision making into Artificial Intelligence (AI) and acceptance thereof (Awad et al., 2018; Cervantes et al., 2020; Moor, 2006). As a preface to AI making moral decisions, the notion of ascribing Morality to these agents needs to be assessed. Therefore, not only ascriptions of Warmth and Competence as social dimensions, but also Morality needs to be evaluated. Research has shown that robots can be ascribed traits similar to the traditional dimensions of Competence (Carpinella et al., 2017; Mandl et al., 2022a), but that ascriptions of more inherently human capabilities such as Warmth (Carpinella et al., 2017) or Sociability and Morality (Mandl et al., 2022a) showed mixed results. Nevertheless, people working with robots tend to ascribe human attributions to robots (Sauppé & Mutlu, 2015). Apart from social perception, design aspects influence how robots are perceived (von der Pütten & Krämer, 2012). While a humanlike, anthropomorphic appearance contributes to perceived trust (de Visser et al., 2016), androids which cannot at first glance be discerned from actual human beings might elicit fear or even disgust (MacDorman, 2019; Mori et al., 2012). This effect, the Uncanny-Valley-

Phenomenon (Mori et al., 2012), is discussed controversly (Bartneck et al., 2007; Rosenthal-von der Pütten et al., 2014; Wang et al., 2015).

Aims and research questions

Synoptically, this study aims at the social perception of Embodied Digital Technologies. To realize more profound insights into this topic and to extend prior research, we focus on two specific application areas, i.e., restoring or augmenting human capabilities by using bionic prostheses and the use of (social) robotics.

While perception of people with disabilities has been widely researched, the effects of differently technologized prostheses is still inconclusive: prior research has shown mixed results in terms of perceived Competence of users of low- and high-tech prostheses. In this study, we aim at replicating and extending the findings of differing social perception of users of prostheses of different Grades of Technicity (Mandl et al., 2022a; Meyer & Asbrock, 2018). We therefore hypothesize that:

H1: People with physical disabilities who use low-tech prostheses are perceived as less competent than people with physical disabilities who use bionic prostheses.

To account for the increase of robots in society, we extend the focus of social perception from human actors to robots. Hannah et al. (2011) mentioned Morality and its effect on ethical and prosocial behavior, cornerstones of functioning societies. This highlights the importance of focusing not only on the SCM-dimension of Warmth, but on Sociability and Morality separately, as proposed by Kervyn et al. (2015). Previous research on social capacities, that is, Competence, Sociability, and Morality, in robots were inconclusive insofar as that only a small percentage of people were willing to ascribe both Sociability and Morality to robots, regardless of their

morphology. Specialized robots such as industrial robots were attributed more Competence than social robots or android robots (Mandl et al., 2022a).

Hence, we pose the following research questions: how are people with physical disabilities and different types of prostheses, able-bodied individuals, and robots of varying levels of anthropomorphism perceived in terms of (RQ1) Competence, (RQ2) Sociability, and (RQ3) Morality.

Methods

Prior to data collection, the study was preregistered on OSF (https://osf.io/6st2b). The procedure was evaluated by the local Ethics Committee. It was not considered to require further ethical approval and hence, as uncritical concerning ethical aspects according to the criteria used by the Ethics Committee, which includes aspects of the sample of healthy adult, voluntary attendance, noninvasive measures, no deception, and appropriate physical and mental demands on the subject. We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study (Simmons et al., 2012).

Participants

We conducted a-priori-power analyses with G*Power (Version 3.1.9.6; Faul et al., 2007) for repeated measures ANOVA with between-factors design with ten measurements. A medium effect size of 0.25 and a correlation of 0.5 among measurements were assumed, and power was set to 0.95. This resulted in a total sample size of 310 participants. The sample was acquired via Prolific Academic (www.prolific.co), an online survey platform (Palan & Schitter, 2018), in two batches to rule out technical issues. Analyses showed that there were no significant differences between the two samples ($N_1 = 122$ and $N_2 = 216$). For all further analyses both samples were added up resulting in a total sample size of $N = 338$. The sample included 186 men, 147 women,

and five participants who identified as non-binary. The average age was 30.99 years (*SD* = 10.37). Most participants were residing in Germany at the time they partook in the study (76.0%) (other countries of residence: Austria: 9.2%, Switzerland: 1.2%, other countries: 13.6%). The sample was highly educated, with 32.8% having obtained a school leaving certificate (German Abitur, Austrian/Swiss Matura) and 50.6% having obtained a university degree. 0.6% stated that they had not obtained any degree, 16.0% stated that they had finished some other education. 8.0% stated that they, or someone in their inner social circle, wear some kind of prosthesis. All participants gave informed consent.

Measures

The stimulus material consisted of 11 pictures of human beings with and without low- and high-tech prostheses, and robots. These pictures correspond to different Grades of Technicity (GoT), ranging from none (able-bodied individual) to very high (android robot). The material can be found on OSF (https://osf.io/qz2ca/). To account for different types of disabilities and prostheses, three types of disabilities (one arm, one leg, both legs) were shown. For each disability, both one low- and one high-tech prosthesis were presented. Two able-bodied individuals, a female and a male, were shown. The pictures were chosen according to the following criteria: neutral to slightly positive facial expression, neutral clothing, neutral background. People with prostheses were exclusively male to control for the influence of female stereotypes.

Furthermore, we presented three pictures of different robots to account for different levels of anthropomorphism: on the lowest level an industrial robot, which does not possess any human-like qualities. On the second level, a social robot (“Pepper”, SoftBank Robotic Europe), which resembles a human being in terms of bodyshape and possesses a face with eyes and a mouth. The highest level of anthropomorphism is represented by an android robot, a still taken

from the movie ROBOLOVE (Arlamovsky, 2019), which is almost indiscernible from a human being. The robots, except for the industrial robot, which was presented in a typical industrial setting, were presented with neutral backgrounds. All pictures were presented in randomized order with the instruction to rate how the participants perceive the person/robot, how they think the person/robot would act/think/react, even though this first impression might be wrong and revoked later. For each picture, the same twentyfive adjectives on opposing ends of a semantic differential were presented in random order and rated on a five-point Likert scale. Pre-Tests (n = 30) revealed that participants hesitated to ascribe more humanlike attributes to robots and stated explicitly that these attributions are not applicable to robots, leading to missing values on these dimensions. To account for these issues and gain minimal information from missing values, we gave two additional choices for robots: “this does not apply to robots in general” and “this does not apply to this specific robot” (Chita-Tegmark et al., 2021). We will present a detailed analysis of missing values in section 5.1.

Items

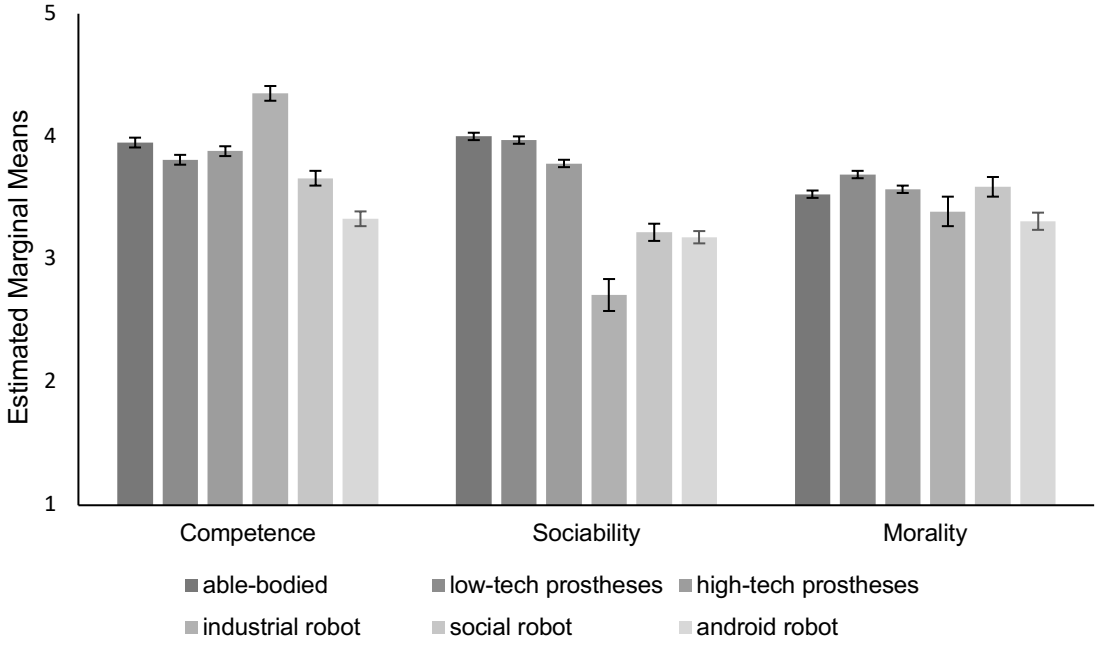
To cover the three main dimensions of social perception, Competence, Sociability, and Morality, we composed items to be rated on a five-point Likert scale. We also assessed perceived Anthropomorphism to ensure that the manipulation of three levels of Anthropomorphism was perceived similarly by the participants.

Competence: we chose three items in line with previous studies (Fiske, 2018; Fiske et al., 2002; Meyer & Asbrock, 2018): competent, independent, and competitive. Reliability analyses showed unsatisfying results if averaged into a scale (McDonald’s ω = .45). We therefore chose to drop two items and use only the item *competent-incompetent* for further analyses (Fig. 1).

Sociability: Sociability was covered by three subscales: warmth (three items, e.g., *warm-cold*; Fiske, 2018; Fiske et al., 2002; Meyer & Asbrock, 2018), animacy (three items, e.g., *lively-stagnant*; Bartneck et al., 2009), and likeability (two items, e.g., *pleasant-unpleasant*; Bartneck et al., 2009). Technical issues accounted for the loss of one item of the animacy scale. Consequently, we dropped this item and proceeded with two items on the animacy scale, resulting in a total of seven items which we averaged into a scale (McDonald's ω = .87, Fig. 1).

Figure 1

Estimated Marginal Mean Scores for Competence, Sociability, and Morality.



Note. N = 338; Competence: $n_{industrial\ robot}$ = 258, $n_{social\ robot}$ = 291, $n_{android\ robot}$ = 266; Sociability: $n_{industrial\ robot}$ = 21, $n_{social\ robot}$ = 79, $n_{android\ robot}$ = 176; Morality: $n_{industrial\ robot}$ = 17, $n_{social\ robot}$ = 48, $n_{android\ robot}$ = 81. Error bars show Standard Errors. See section 5.1 for a detailed analysis of missing values.

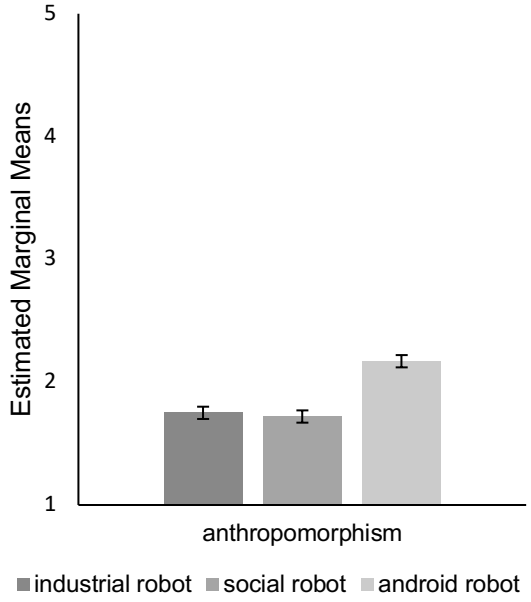
Morality: we adapted eight attributions, which people high in Moral Identity possess (e.g., *fair-unfair*), of the German version of the Moral Identity Questionnaire (Aquino & Reed,

2002) based on theoretical considerations, that is, intelligibility and relevance, and chose corresponding antonyms. We averaged these items into a scale (McDonald's ω = .82, Fig. 1).

Anthropomorphism: We used five items of the Godspeed Questionnaire (Bartneck et al., 2009) to assess perceived anthropomorphism of the robotic stimuli (e.g., *humanlike-machinelike*). We averaged these items into a scale and analyzed the reliability for this sample (McDonald's ω = .89, Fig. 2).

Figure 2

Estimated Marginal Mean Scores for Anthropomorphism.



Note. $N = 338$; $n_{industrial\ robot} = 175$, $n_{social\ robot} = 184$, $n_{android\ robot} = 213$. Error bars show Standard Errors. See section 5.1. for a detailed analysis of missing values.

Procedure

After giving informed consent and filling in a sociodemographic questionnaire, participants were presented with the stimulus material. They rated each visual stimulus on 25 adjectives that comprised the six (sub-)scales Competence, Warmth, Animacy, Likeability, Morality, and

Anthropomorphism. Afterwards, participants completed the ATI[5] scale (M = 4.23, SD = 1.01) (Franke et al. 2019) and the NFC[6]-K scale (M = 4.79, SD= 1.11) (Beißert et al., 2014). However, these two personality questionnaires were out of the scope of this study, and will be used for further analysis. Lastly, we asked whether the participants themselves or any of their acquaintances used prostheses. Upon finishing, participants were forwarded to Prolific Academic (www.prolific.co) to receive a compensation of EUR 3.20. The total processing time was approximately 20 min.

Statistical analysis

By employing a within-subject design, which is quite common in organizational research or HRI research, (e.g., Scheunemann et al., 2020), all participants rated all of the eleven pictures. These eleven repeated measurements of the dependent variables were thus nested in participants and are therefore highly likely to be non-independent. This was the case for Competence, ICC(1) = .19, $F_{(377, 1491)} = 2.26$, $p < .001$, ICC(2) = .56, Sociability, ICC(1) = .29, $F_{(337, 1010)} = 2.64$, $p < .001$, ICC(2) = .62, and Morality, ICC(1) = .51, $F_{(337, 822)} = 4.57$, $p < .001$, ICC(2) = .78. From a merely statistical point of view, as mentioned above, nested data can basically be thought as repeated measures within the subject, these repeated measures per subject led to correlated errors. These non-independent errors prohibit the use of standard procedures like ANOVA or linear regression models (Bliese et al., 2018; Seltman, 2009). We thus employed Mixed Models, which in a nutshell, give correct estimates in the presence of correlated errors, to account for nested data and the effects that come with it.

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[5] Affinity for Technology Interaction
[6] Need for Cognition

We used R (Version 4.1.1; R Core Team, 2021) and the Rpackages dplyr (Version 1.0.7), tidyverse (Version 1.3.1), tidyr (Version 1.1.3), forcats (Version 0.5.1) for data management, psych (Version 2.1.6), sjstats (Version 0.18.1), ggpubr (Version 0.4.0), sjplot (Version 2.8.9), lm.beta (Version 1.5-1), apaTables (Version 2.0.8), and ggplot2 (Version 3.3.5) for descriptive analyses, MuMln (Version 1.43.17), effects (Version 4.2-0), emmeans (Version 1.6.2.1), mulitlevel (Version 2.6), stats (Version 4.0.2), lme4 (Version 1.1-27.1), pbkrtest (Version 0.5.1) and lattice (Version 0.20-44) for fitting Mixed Models and subsequent post-hoc testing.

Results

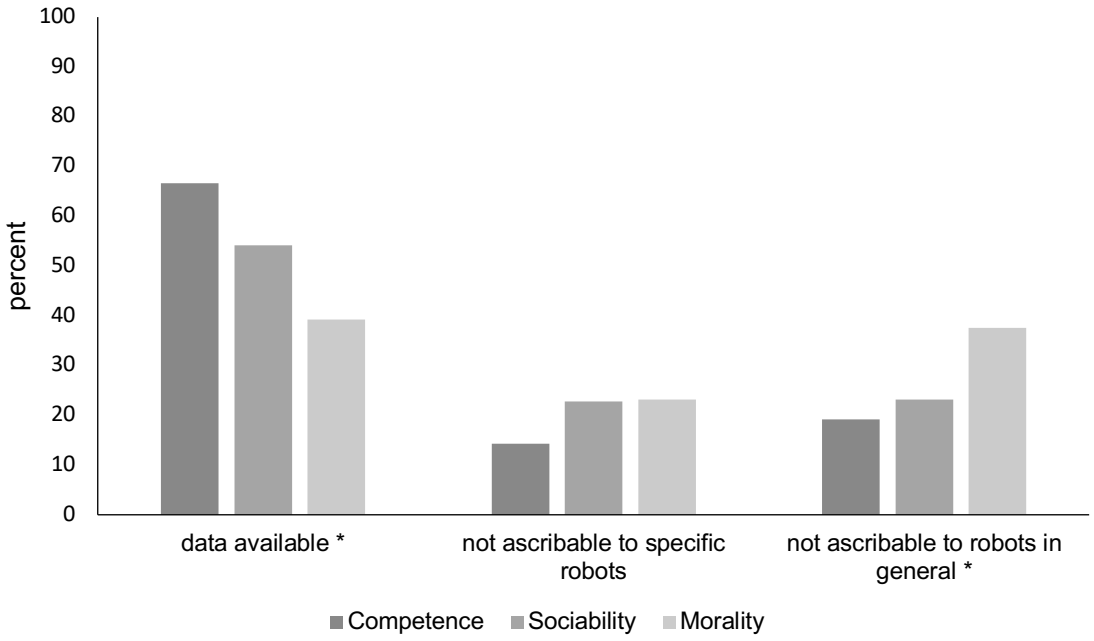
Visual inspection of the data revealed a non-linear relationship of Grade of Technicity with Competence, Sociability, and Morality (cf. Fig. 1). To account for the apparent break between human and robotic stimuli, we decided to split the data for all three attributions into two subgroups. These subgroups were built by splitting the data by stimuli into a “human” and a “robotic” subgroup, regarding the fact that every participant rated all stimuli; both subgroups were equal in size ($N = 338$). The structure of the data for human stimuli furthermore revealed that restored functionality, that is, to regain abilities comparable to able-bodied individuals, seemed to explain differences in attributions better than technicity of the prostheses.

Missing values

We analyzed the two additional categories for attributions of Competence, Sociability, and Morality for the robotic stimuli (“*this does not apply to all robots*” and “*this does not apply to this specific robot*”) to further evaluate the pattern of answers (Fig. 3).

Figure 3

Distribution of answering options for robots for social perceptions.



Note. Distribution of which percentage of participants agreed that Competence, Sociability, or Morality can be ascribed to robots. χ2 was computed to evaluate differences between attributions for the three answering options.

* $p < .05$.

We found significant differences in the ascription of attributions to robots, $\chi^2 = 7.02$, $df = 2$, $p = .030$, no differences in the willingness to attribute social dimensions to industrial robots, social robots, or android robots, $\chi^2 = 2.51$, $df = 2$, $p = .286$, and significant differences in the ascription of attributions to robots in general, $\chi^2 = 7.09$, $df = 2$, $p = .029$. Out of 338 participants, only 17 attributed adjectives concerned with Morality to the industrial robot, 48 to the social robot, and 81 to the android robot. Participants were comparably unwilling to attribute Sociability to robots: 21 attributed Sociability to industrial robots, 79 to the social robot, and 176

to the android robot. For Competence, these differences were not as large: 258 participants attributed Competence to the industrial robot, 291 to the social robot, and 266 to the android robot.

We therefore need to limit the interpretations of attributions of Sociability and Morality in such a way that, at present, participants did not agree that robots could be attributed these social dimensions.

Results: Human stimuli

To test our hypothesis and research questions, we ran a Mixed Model regressing Competence on restored functionality. A model with random intercept fit the data best (Table 1), indicating that restored functionality was positively associated with attributions of Competence. Posthoc Tukey tests revealed that users of low-tech prostheses were not perceived as less competent than users of bionic prostheses, $\Delta M = 0.07$, $SE = 0.03$, $p = .085$, $d = 0.16$, thus rejecting hypothesis H1. The analysis of RQ1 revealed that users of low-tech prostheses were perceived as less competent than able-bodied individuals, $\Delta M = 0.14$, $SE = 0.03$, $p < .001$, $d = 0.34$. No significant differences of perceived Competence were found between users of bionic prostheses and able-bodied individuals, $\Delta M = 0.08$, $SE = 0.03$, $p = .055$, $d = 0.18$. Control variables of gender and education were associated with attributions of Competence: female participants attributed significantly more Competence than male participants, $\Delta M = 0.18$, $SE = 0.06$, $p = .011$, $d = 0.43$. Age was negatively associated with attributions of Competence, $b = –0.01$, $SE = 0.00$, $t = –2.45$.

Table 1

Comparison of Fit Indices for Linear Mixed Models regressing Competence on Restored Functionality for human stimuli

Predictors	Model 0			Model 1			Model 2		
	b	*SE*	*CI*	*b*	*SE*	*CI*	*b*	*SE*	*CI*
(Intercept)	3.88	0.03	[3.82, 3.94]	3.74	0.05	[3.65, 3.82]	4.25	0.21	[3.82, 4.67]
RF				0.07	0.02	[0.04, 0.10]	0.07	0.02	[0.04, 0.10]
Gender							-0.16	0.06	[-0.28, -0.04]
Age							-0.01	0.00	[-0.01, -0.00]
Education							-0.01	0.03	[-0.07, 0.05]
Random Effetcs									
σ^2	0.18			0.18			0.18		
τ_{00}	0.27_{id}			0.27_{id}			0.26_{id}		
τ_{11}									
ρ_{01}									
ICC	.60			.61			.60		
Model Fit									
Marginal R^2	0.000			0.008			0.034		
Conditional R^2	0.599			0.610			0.612		
AIC	1737.5			1726.5			1738.9		
BIC	1752.3			1746.2			1773.4		
$\chi 2$				13.07**			0.00		

Note. N = 338, Observations = 1014; RF = Restored Functionality. CI = 95% confidence interval. Bootstrap confidence intervals were constructed using 10 000 resamples.

For research question RQ2, which we posed to evaluate whether there would be differences in perceived Sociability for users of low- or high-tech prostheses and able-bodied individuals, we ran a Mixed Model regressing Sociability on restored functionality. Results did not reveal a significant association between restored functionality and Sociability (Table 2). Instead, again, the control variable gender was associated with attributions of Sociability: female participants attributed significantly more Sociability than male participants, $\Delta M = 0.14$, $SE = 0.05$, $p = .026$, $d = 0.42$.

Table 2

Comparison of Fit Indices for Linear Mixed Models regressing Sociability on Restored Functionality for human stimuli

Predictors	Model 0			Model 1			Model 2		
	b	*SE*	*CI*	*b*	*SE*	*CI*	*b*	*SE*	*CI*
(Intercept)	3.86	0.03	[3.27, 3.43]	3.88	0.04	[2.55, 3.74]	4.36	0.18	[4.02, 4.70]
RF				-0.01	0.01	[-0.07, 0.15]	-0.01	0.01	[-0.03, 0.02]
Gender							-0.15	0.05	[-0.25, -0.05]
Age							-0.00	0.00	[-0.01, 0.00]
Education							-0.02	0.02	[-0.07, 0.02]
Random Effects									
σ^2	0.10			0.10			0.10		
τ_{00}	0.19 $_{id}$			0.19 $_{id}$			0.18 $_{id}$		
ICC	.65			.65			.64		
Model Fit									
Marginal R^2	0.000			0.001			0.026		

	Model 0	Model 1	Model 2
Conditional R^2	0.646	0.646	0.648
AIC	1229.8	1238.2	1252.4
BIC	1244.5	1257.9	1286.8
$\chi 2$		0.00	0.00

Note. N = 338, Observations = 1014; RF = Restored Functionality. CI = 95% confidence interval. Bootstrap confidence intervals were constructed using 10 000 resamples.

For research question RQ3, concerned with whether there would be differences in perceived Morality for users of low- or high-tech prostheses and able-bodied individuals, we ran a Mixed Model regressing Morality on restored functionality. We found that restored functionality was negatively associated with Morality (Table 3). Post-hoc Tukey test revealed that users of low-tech prostheses were attributed significantly more Morality than users of high-tech prostheses, $\Delta M = 0.12$, $SE = 0.02$, $p < .001$, $d = 0.47$, and able-bodied individuals, $\Delta M = 0.16$, $SE = 0.02$, $p < .001$, $d = 0.65$. Attributions of Morality for users of high-tech prostheses and able-bodied individuals did not differ significantly but showed a tendency $\Delta M = 0.05$, $SE = 0.02$, $p = .050$, $d = 0.18$. None of the control variables were significantly associated with perceptions of Morality.

Table 3

Comparison of Fit Indices for Linear Mixed Models regressing Morality on Restored Functionality for human stimuli

Predictors	Model 0			Model 1			Model 2			Model 3		
	b	*SE*	*CI*	*b*	*SE*	*CI*	*b*	*SE*	*CI*	*b*	*SE*	*CI*
Intercept	3.60	0.02	[3.55, 3.64]	3.76	0.03	[3.70, 3.82]	3.76	0.03	[3.70, 3.82]	4.13	0.16	[3.81, 4.44]
RF				-0.08	0.01	[-0.10, -0.06]	-0.08	0.01	[-0.10, -0.06]	-0.08	0.01	[-0.10, -0.06]
Gender										-0.06	0.04	[-0.15, 0.03]
Age										0.00	0.00	[-0.01, 0.00]
Education										-0.04	0.02	[-0.08, 0.01]
Random Effects												
σ^2	0.07			0.06			0.05			0.06		
τ_{00}	0.16 $_{id}$			0.16 $_{id}$			0.19 $_{id}$			0.16 $_{id}$		
τ_{11}							0.01 $_{id\ rf}$					
ρ_{01}							-0.38 $_{id}$					
ICC	.69			.71			.77			.71		
Model Fit												
Marginal R^2	0.000			0.020			0.020			0.032		
Conditional R^2	0.690			0.719			0.772			0.721		

	Model 0	Model 1	Model 2	Model 3
AIC	900.38	842.44	832.00	863.45
BIC	915.14	862.00	861.53	897.90
$\chi 2$		59.94**	14.44**	0.00

Note. N = 338, Observations = 1014; RF = Restored Functionality. CI = 95% confidence interval. Bootstrap confidence intervals were constructed using 10 000 resamples.

Results: robotic stimuli

Research questions proposed that different levels of anthropomorphism could be associated with different attributions of Competence (RQ1), Sociability (RQ2), and Morality (RQ3). We therefore needed to establish whether the manipulation was successful. We ran a corresponding Mixed Model regressing attributed Anthropomorphism on Grade of Technicity which showed that Anthropomorphism differed between robot types, $b = 0.22$, $SE = 0.03$, $t = 7.21$, $p < .001$. Surprisingly, results showed that the industrial robot was not perceived as less anthropomorphic than the social robot, $\Delta M = 0.03$, $SE = 0.06$, $p = .868$, $d = 0.06$. The industrial robot was perceived as less anthropomorphic than the android robot, $\Delta M = –0.42$, $SE = 0.06$, $p < .001$, $d = 0.76$. The social robot was perceived as less anthropomorphic than the android robot, too, $\Delta M = –0.45$, $SE = 0.06$, $p < .001$, $d = .81$. Control variable gender was associated with perceived Anthropomorphism: female participants attributed less Anthropomorphism than male participants, $\Delta M = –0.18$, $SE = 0.07$, $t = –2.61$, $p = .026$.

To answer research question RQ1, whether robots with varying levels of Anthropomorphism would be perceived differently in terms of attributed Competence, we ran a Mixed Model regressing Competence on Grade of Technicity. We found that Anthropomorphism was negatively associated with Grade of Technicity (Table 4). Post-hoc Tukey test revealed that the industrial robot was perceived as more competent than the social robot, $\Delta M = 0.69$, $SE = 0.08$, $p < .001$, $d = 0.72$, and the android robot, $\Delta M = 1.02$, $SE = 0.08$, $p < .001$, $d = 1.07$. The social robot was perceived as more competent that the android robot, $\Delta M = 0.33$, $SE = 0.08$, $p < 0.001$, $d =0.35$. Control variables gender and age were associated with perceived Competence. Female participants attributed significantly more Competence than male

Table 4

Comparison of Fit Indices for Linear Mixed Models regressing Competence on Grade of Technicity for robotic stimuli

Predictors	Model 0			Model 1			Model 2			Model 3		
	b	*SE*	*CI*	*b*	*SE*	*CI*	*b*	*SE*	*CI*	*b*	*SE*	*CI*
Intercept	3.77	0.04	[3.69, 3.86]	6.31	0.22	[5.89, 6.73]	6.32	0.23	[5.87, 6.77]	7.29	0.34	[6.61, 7.96]
RF				-0.51	0.04	[-0.59, -0.42]	-0.51	0.04	[-0.60, -0.42]	-0.51	0.04	[-0.59, -0.42]
Gender										-0.33	0.08	[-0.48, -0.18]
Age										-0.01	0.00	[-0.02, -0.01]
Education										-0.01	0.04	[-0.09, 0.07]
Random Effects												
σ^2	1.14			0.91			0.81			0.91		
τ_{00}	0.12 $_{id}$			0.19 $_{id}$			3.09 $_{id}$			0.15 $_{id}$		
τ_{11}							0.11 $_{id.got}$					
ρ_{01}							-0.96 $_{id}$					
ICC	.10			.17			.26			.14		
Model Fit												
Marginal R^2	0.000			0.131			0.132			0.166		
Conditional R^2	0.098			0.278			0.358			0.286		

	Model 0	Model 1	Model 2	Model 3
AIC	2509.5	2385.7	2386.0	2382.0
BIC	2523.6	2404.5	2414.2	2414.9
$\chi 2$		125.83**	3.70	6.04*

Note. N = 316, Observations = 815; GOT = Grade of Technicity. CI = 95% confidence interval. Bootstrap confidence intervals were constructed using 10 000 resamples.

participants, $\Delta M = 0.37$, $SE = 0.08$, $p < .001$. Age was negatively associated with attributed Competence, $b = –0.01$, $SE = 0.00$, $t = –3.30$.

Research question RQ2 was concerned with whether there would be differences in perceived Sociability for different robots. We ran a Mixed Model regressing Sociability on Anthropomorphism and found that Anthropomorphism was not associated with perceived Sociability (Table 5). None of the control variables showed significant associations with perceived Sociability.

Table 5

Comparison of Fit Indices for Linear Mixed Models regressing Sociability on Grade of Technicity for robotic stimuli

Predictors	Model 0			Model 1			Model 2		
	b	*SE*	*CI*	*b*	*SE*	*CI*	*b*	*SE*	*CI*
(Intercept)	3.35	0.04	[3.27, 3.43]	3.25	0.14	[2.53, 3.72]	3.38	0.31	[2.43, 4.06]
GOT				0.04	0.06	[-0.07, 0.15]	0.04	0.06	[-0.07, 0.15]
Gender							-0.07	0.08	[-0.23, 0.09]
Age							0.01	0.00	[-0.00, 0.01]
Education							-0.04	0.04	[-0.12, 0.04]
Random Effects									
σ^2	0.34			0.34			0.34		
τ_{00}	0.11 $_{id}$			0.11 $_{id}$			0.11 $_{id}$		
ICC	.25			.25			.25		

	Model 0	Model 1	Model 2
Model Fit			
Marginal R^2	0.000	0.001	0.012
Conditional R^2	0.251	0.249	0.258
AIC	686.45	691.87	711.73
BIC	697.88	707.12	738.41
$\chi 2$		0.00	0.00

Note. N = 206, Observations = 334; GOT = Grade of Technicity. CI = 95% confidence interval. Bootstrap confidence intervals were constructed using 10 000 resamples.

For research question RQ3, whether there would be differences in perceived Morality for different robots, we ran a Mixed Model regressing Morality on Grade of Technicity and found that perceived Morality was negatively associated with Grade of Technicity (Table 6). Post-hoc Tukey test revealed that the social robot was attributed more Morality than the android robot, $\Delta M = 0.28$, $SE = 0.07$, $p < .001$, $d = 0.85$. Perceived Morality did not differ significantly between the social robot and the industrial robot, $\Delta M = –0.20$, $SE = 0.11$, $p = .178$, $d = 0.60$, and between the industrial robot and the android robot, $\Delta M = 0.08$, $SE = 0.11$, $p = .739$, $d = 0.25$.

Table 6

Comparison of Fit Indices for Linear Mixed Models regressing Morality on Grade of Technicity for robotic stimuli

Predictors	Model 0			Model 1			Model 2		
	b	*SE*	*CI*	*b*	*SE*	*CI*	*b*	*SE*	*CI*
(Intercept)	3.40	0.06	[3.27, 3.52]	3.69	0.15	[3.45, 4.65]	3.38	0.49	[2.63, 4.83]

Predictors	Model 0			Model 1			Model 2		
	b	*SE*	*CI*	*b*	*SE*	*CI*	*b*	*SE*	*CI*
GOT				-0.12	0.05	[-0.22, -0.01]	-0.12	0.05	[-0.22, -0.01]
Gender							0.05	0.14	[-0.22, 0.32]
Age							0.00	0.01	[-0.01, 0.02]
Education							0.02	0.06	[-0.11, 0.14]
Random Effects									
σ^2	0.14			0.13			0.13		
τ_{00}	0.29 $_{id}$			0.30 $_{id}$			0.31 $_{id}$		
ICC	.68			.70			.71		
Model Fit									
Marginal R^2	0.000			0.015			0.021		
Conditional R^2	0.679			0.702			0.712		
AIC	266.43			267.78			286.84		
BIC	275.38			279.72			307.73		
$\chi 2$				0.64			0.00		

Note. N = 94, Observations = 146; GOT = Grade of Technicity. CI = 95% confidence interval. Bootstrap confidence intervals were constructed using 10 000 resamples.

Discussion

The present study was aiming at answering two major research questions to replicate findings by Meyer and Asbrock (2018) and Mandl et al. (2022a): (1) How are users of pros theses and

(2) different robots perceived in terms of the three major dimensions of social perception: Competence, Sociability, and Morality?

As we pointed out in section 5, data inspection revealed a non-linear relationship between the Grade of Technicity (GOT) and the assessed attributions. Therefore, we divided the dataset by compiling data via the stimuli into a “human” subset and a “robot” subset. Moreover, although the construct Grade of Technicity can basically be applied to both samples, it is necessary to create a more suitable category for the human subsample due to content considerations. Based on these considerations, the category Grade of Technicity seems inappropriate for users of bionic prostheses, especially in comparison to the stimuli of non-disabled people. It seems more salient for the evaluation that a human is a human, and even with an accentuation in the direction of a cyborg, the primary humanoid attribution remains. Consequently, we introduced the construct Restored Functionality (RF) to describe the human sample. Accordingly, the following discussion will be conducted along these two subsamples and the corresponding constructs mentioned above.

Social perception of human beings with prostheses

We hypothesized that people with bionic prostheses are perceived as more competent than people with low-tech prostheses. The present data did not support this hypothesis: users of bionic prostheses were perceived as competent as people with low-tech prostheses, further supported by a very small effect size. Instead, we found that people with low-tech prostheses were perceived as less competent than able-bodied people, which in turn was not true for users of bionic prostheses: they were perceived as being as competent as able-bodied individuals. These findings are only partly in line with previous findings: users of bionic prostheses were found to be perceived as more competent than people with physical disabilities in general Meyer and

Asbrock (2018) and users of low-tech prostheses (Mandl et al., 2022a), but as less (Meyer & Asbrock, 2018) or equally as (Mandl et al., 2022a) competent as able-bodied individuals. Users of low-tech prostheses apparently fall in the space between these two categories, as they are perceived as competent as users of bionic prostheses, but less competent than able-bodied individuals. We interpret this in such a way that prostheses, regardless of their technicity, account for more perceived Competence. As for users of bionic prostheses, our findings deviated in such a way that they were perceived as competent as users without physical disabilities. This indicates that technicity of the prostheses might contribute to perceived Competence, but only marginally. However, further research will have to show whether these differences in perceived Competence persist. People with disabilities are, in general, perceived as warmer than able-bodied people (Fiske, 2018; Fiske et al., 2002; Meyer & Asbrock, 2018).

By dividing the dimension of Warmth into Sociability and Morality (Kervyn et al., 2015; Leach et al. 2007), we were aiming at replicating prior findings. In line with Mandl et al. (2022a), people with disabilities, regardless of the type of protheses, were perceived as sociable as able-bodied people. We found differences between people with low-tech prostheses and both users of bionic prostheses and able-bodied individuals in perceived Morality, which is mostly in line with prior findings, where more Morality was attributed to people with low-tech prostheses than able-bodied individuals, but no difference between users of bionic prostheses and able-bodied individuals was found (Mandl et al., 2022a). We suspect that this might be due to the fact that the common stereotype of people with physical disabilities includes attributions of being tolerant and sincere (Fiske et al., 2002) in the dimension of Warmth, which correspond to Morality rather than Sociability. Our findings indicate that using such devices affects how others perceive users and might induce specific behaviors towards them. For example, using bionic

prostheses positively affects the acceptance of disabled people at work conveyed by the ascribed Competence (Vornholt et al., 2013), similar to able-bodied individuals. We expect that augmenting devices will also trigger these processes of social perception with positive and rather negative outcomes, as partially shown by Gilotta et al. (2019) and Siedl and Mara (2021). Consequently, in upcoming studies, we will explicitly address devices for augmenting user capabilities and also focus on more work-related applications like exoskeletons.

Social perception of robots

We employed an adapted version of the SCM Model, which includes the social dimensions Competence, Sociability, and Morality to robots of different levels of technicity. We assumed that higher levels of technicity are linked to higher levels of Anthropomorphism.

Less anthropomorphized robots were perceived as more competent than more anthropomorphized robots, which is in line with previous findings (Mandl et al., 2022a). We assume that this might be caused by the clear application area of industrial robots whereas intended use of social robots and androids might be not that obvious.

Surprisingly, and in contrast to Mandl et al. (2022a), where industrial robots were perceived as less sociable than more anthropomorphized robots, attributions of Sociability did not differ between robots of different anthropomorphic levels. Instead, robots were seen as comparably sociable. More Morality was attributed to the social robot than the android robot, with the industrial robot falling in between. This counteracts the finding that Morality did not differ as a function of anthropomorphism (Mandl et al., 2022a). We need to point out that by further investigating, we found that less participants ascribed inherently humane attributions such as Sociability and Morality to robots. This might be the reason for the divergent results found in previous studies. Therefore, these results should be seen as preliminary and require further

research. We assume that this might be partly explained by the fact that the majority of people are not in direct contact with robots. There is evidence that attitudes towards robots are currently based on fiction rather than objective reality (Naneva et al., 2020). Moreover, based on intergroup relation research, Sarda Gou et al. (2021) could show that direct contact with robots positively affected participants' attitudes toward robots. We found rather reserved attributions to robots. Further studies should address whether differences in perception persist if people work with robots or not, and whether perceptions in work settings can be conferred to social settings. We assume that attitudes towards and emotions evoked by robots will become more realistic and objective in the long run, so that longitudinal studies should be conducted to assess and monitor those changes.

Limitations

We evaluated the social perception of robots and individuals with and without physical disabilities with low- and high-tech prostheses by presenting pictures. These static stimuli do not take into account the effects of motion, which is thought to influence how robots are perceived (Kupferberg et al., 2011). For that reason, the present research has to be seen as a first step towards a better understanding of the social perception of robots. Also pictures of individuals are highly influenced by personal taste, so since we decided on presenting pictures of actual human beings, they, of course, differed in their physical appearance which might have influenced their perception. Furthermore, we used scales from the Godspeed Inventory (Bartneck et al., 2009) and the SCM (Fiske 2018; Meyer and Asbrock 2018), since we not only investigated perceptions of robots but also of human beings. This decision comes with certain limitations: Due to reliability issues we decide to use a single item Competence measure. Additionally, technical issues accounted for the loss of one item of the animacy scale for the social robot within the first

sample. Furthermore, only a small number of participants were willing to attribute Sociability and Morality to robots. We will address those limitations in upcoming experimental and field studies.

Conclusion

We were able to show that people with low- and high-tech prostheses and able-bodied individuals are perceived differently in terms of Competence and Morality, whereas we found no differences in perceived Sociability. Social perception differs between robots with more or less anthropomorphic appearances. In general, typically humane attributions such as Morality cannot be transferred to robots without issues. In contrast, attributions of Competence and, in part, Sociability can be ascribed to robots more easily. Although the primary aim was to generate more profound insights into the social perception of EDTs on a general level by replicating prior research on bionic devices for restoring user capabilities and enriching those research with (social) robotics, first practical implications can be derived from our findings. As shown, the use of bionic technologies can affect stereotypes and interpersonal perceptions. The introduction of exoskeletons and similar technologies in future work contexts, for example, might thus have unintended social repercussions that need to be accounted for.

Concerning (social) robots, these exploratory results should be considered when designing robots that will be used in primarily social environments or at least when implementing robots into work settings. To realize this in praxi we suggest to assess the social perception of when implementing robots to prescreen their acceptance by the users who directly work with these EDTs to become aware of and mitigate possible unintended side effects. An economical and easy-to-implement approach might be using the Social Perception of Robots Scale (SPRS) developed by the authors (Mandl et al., 2022b).

Author Contribution

AS, FA, BM, SM, and MB had the original idea for the study. SM and MB collected and analyzed the data and wrote the manuscript. AS, FA and BM provided comprehensive internal review.

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Conflict of interest

M. Bretschneider, S.Mandl, A. Strobel, F. Asbrock and B. Meyer declare that they have no competing interests.

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The impact of bionic prostheses on users' self-perceptions: A qualitative study

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Abstract

Bionic devices for reestablishing or augmenting users' capabilities (e.g., bionic prostheses or exoskeletons) are becoming increasingly common. While prior research examined how such devices affect others' perceptions of their users, little is known about how these devices affect users' self-image and -perception, and the corresponding theory is scarce. To account for this gap, we conducted semi-structured interviews with users of bionic upper limb prostheses to obtain insights into their self- and meta-perceptions. Results of our qualitative analysis indicate that using bionic prostheses influences the social (self-) perception of bionics users in multiple ways, such that users describe themselves as being seen as more competent by others and treated differently after receiving the bionic prosthesis in comparison to simpler models. Results imply a somewhat complex dual identity among users in the sense that the bionic device instills competence, but disability-related feelings of stigma are present simultaneously. Despite being exploratory, our findings thus indicate that using bionic devices affects users' self-perception, stereotypes, and interpersonal perceptions. The ongoing proliferation of restoring devices and the introduction of augmenting technologies in future work contexts, for example, might thus have unintended social consequences that need to be accounted for.

Introduction

Contemporary societies are characterized by technological change and the increasing use of (embodied) technologies, such as augmented and virtual reality devices, (social) robots, and bionic devices for reestablishing or augmenting user capabilities (e.g., bionic prostheses or exoskeletons). These devices will soon become more prevalent, and their proliferation has the potential to fundamentally alter the way we live and work, as they are likely to affect how users and non-users of such technologies perceive each other and interact with each other (Meyer & Asbrock, 2018).

Bionic[7] devices are defined as "systems whose foundation is based on living systems, or which have characteristics of living systems, or which resemble them" (Roth, 1983, p. 229). We use the term in the medical sense for devices that technologically replace or enhance body parts and (motor) capabilities and are thus worn for extended periods of time. Given the tight coupling of (social) cognition and aspects of the body, such as its sensory and motor capabilities (e.g., Varela et al., 2017), these devices are likely to psychologically affect users' self-image and how they are perceived by others, especially if worn over extended periods of times as in the context of prostheses or bionic work tools. While we are not treating future work-related body augmentation technologies such as exoskeletons as equivalent to wearing a prosthesis, we propose that investigating the effect of wearing a modern bionic prosthesis on users can provide

[7] In this paper, we use the term "bionic" to refer to technology that mimics the functionality of the human body, which includes multiarticulate or multigrip hands. While the term "multiarticulate hand" is common in prosthetics research, we have opted for the more widely understood term "bionic" to enhance clarity for a broader readership.

meaningful insights into the potential social-psychological consequences of the future proliferation of bionic devices that aim to enhance the function of the average human body.

Given the scarcity of research on the psychological effects of wearing bionic prostheses, we conducted a qualitative study with a sample of highly proficient users of bionic prostheses. With this approach, we aim to identify core psychological concepts that are affected by wearing a bionic prosthesis and the potential psychological processes underlying these effects. Specifically, while prior research on wearing a prosthesis focused on their perceived functional usefulness and on their cosmestics in terms of looking 'normal' (Saradjian et al., 2008), we leave room for the possibility that modern bionic prostheses can affect feelings of self- worth in other ways than by mimicking the appearance of a natural body part. In so doing, we also aim to assess the suitability of employing the Stereotype Content Model (SCM; Fiske et al., 2007) as a useful theory for explaining the effects of bionic prostheses on self- and other- perception. In a nutshell, our study seeks thus to answer the question of how wearing a bionic prosthesis affects self- and other-perceptions from the users' perspective.

In the following section, we review existing research surrounding this question before describing our method, results, and our interpretations.

Bionic prosthesis and users' self-perceptions

Limb loss, regardless of whether acquired or congenital, has far- reaching psychological consequences for the individual. Prostheses compensating for the absence of a limb are typically seen as serving two functions by medical professionals (Saradjian et al., 2008): First, a prosthesis is supposed to provide a functional benefit, in the sense that it should enable the individual to perform functions or activities that require the missing limb and that would be more difficult or impossible to perform without the prosthesis. Examples include walking for individuals who use

a leg prosthesis, or bimanual activities such as cooking or tying shoelaces for individuals who use an arm prosthesis. Second, a prosthesis is seen as serving a cosmetic function (Saradjian et al., 2008) in the sense that it is supposed to make the disability, which is typically associated with a stigma (Barg et al., 2010; Rohmer & Lou- vet, 2016), less visible.

The advent of modern bionic prostheses such as multiarticulate bionic hands with sensors, many motors, and adaptive grip patterns, and bionic legs with sensor-controlled hydraulic knee joints and carbon blade feet (e.g., Meyer & Asbrock, 2018) has the potential to change the psychological cosmetic aspect of the prosthesis. Such devices often have a modern, technological appearance and feature prominently and positively in many media discourses (Meyer & Asbrock, 2018). They are often used to illustrate the onset of a transhumanist future where tech- nology enables overcoming the limits of the human body (Meyer & Asbrock, 2018).

Given the stigma typically associated with a physical disability as being in an inferior state (Rohmer & Louvet, 2016), such technologically advanced bionic limbs that potentially signal anything but inferiority are likely to have a profound effect on their users. Research on embodied cognition (for an overview, see Varela et al., 2017) has long demonstrated that perceptions and consciousness are shaped by features of the human body, especially by its sensor and motor capabilities. For example, limb loss or absence is associated with the substantial reorganization of the motor cortex, where the affected limbs or functions are represented and in neighboring areas representing compensatory functions (Hahamy et al., 2017; Root et al., 2022). Using a hand prosthesis even results in a cortical representation of the affected hand that is neither akin to a human limb nor to a tool (Maimon-Mor & Makin, 2020), further demonstrating the impact that using a bionic arm can have on the users' cognition and cortical organization.

Against this backdrop, we find it surprising that psychological studies on the effect of wearing a bionic limb on users are absent from the literature. The scarce existing literature exclusively focuses on how others perceive artificial body parts or bodies. Early research in this area investigated the Uncanny Valley phenomenon (Mori et al., 2012), according to which high levels of human-likeness of technology, that is just shy of a perfect human resemblance, trigger negative emotions like unease. While this research implies that prostheses attempting to mimic the appearance of human body parts (e.g., skin-colored artificial hands) can result in unfavorable attributions toward their wearers, this research stays mute on the consequences of bionic devices whose appearance is more technical, like modern bionic prostheses, and on the users' perspective.

Specific research on the effects of bionic prostheses on self- and other-perceptions and on the individual and societal consequences of using bionic technologies is rare. A recent study (Meyer & Asbrock, 2018) proposed adopting the SCM (Fiske et al., 2002) and its extension into the Behaviors from Intergroup Affect and Stereotypes (BIAS) map (Cuddy et al., 2007, 2008) as a theoretical foundation for investigating other-perceptions toward users of bionic prostheses. According to these theories, humans evaluate other humans and themselves among the two main dimensions of attributed warmth (ranging from warm good intentions to cold bad intentions) and competence (ranging from incompetent to competent). For example, individuals with physical disabilities are typically perceived as warm and incompetent (Asbrock, 2010; Barg et al., 2010; Meyer & Asbrock, 2018). According to the BIAS map (Cuddy et al., 2008), societal groups perceived as warm typically elicit active facilitation (help) or active harm (attack), while groups perceived as competent tend to elicit passive facilitation (cooperate) or passive harm (ignore). These effects are mediated by specific emotions, namely, admiration, envy, contempt, and pity

(Becker & Asbrock, 2012; Cuddy et al., 2008). The SCM and BIAS map imply ambivalent relationships between warmth and competence, such that increasing attributions of competence cooccur with decreased attributions of warmth. This suggests that a user of a bionic prosthesis is likely to elicit negative emotions (e.g., envy, fear, anger) if the user is perceived as competent because the user is likely to also come across as cold. Therefore, according to Meyer and Asbrock (2018), wearing a bionic prosthesis can be associated with social repercussions. Specifically, the authors investigated attributions of warmth and competence toward abstract concepts such as 'people with physical disabilities', 'people with physical disabilities who use bionic prostheses', and 'cyborgs'.

Their study participants attributed different levels of competence and warmth to these labels: Participants rated people with physical dis- abilities who use bionic prostheses as more competent but equally warm as people with physical disabilities. Participants rated cyborgs as much colder than the other two categories. This study was, however, unable to replicate these findings when using photographs of people who wear prostheses as stimulus material and was unable to uncover underlying psychological processes.

Further, recent studies (Bretschneider et al., 2022; Mandl et al., 2022) also investigated how people using various types of prostheses are perceived by others. Mandl et al. (2022) showed that individuals with low-tech prostheses tend to be perceived as less competent than able- bodied individuals and users of high-tech prostheses, while the latter two groups are typically perceived as similarly competent. However, Bretschneider et al. (2022) could not replicate the findings that low-tech prostheses are associated with low levels of attributed competence. However, they could show once more that users of bionic prostheses are seen as competent as able-bodied individuals. Instead of investigating attributions of warmth, these

studies investigated attributions of sociability (perceptions of likeableness and warmth) and morality (perceptions regarding the morality of the other's intentions). Sociability did not differ between users of low-tech or bionic prostheses or able-bodied individuals, and perceived morality was higher for users of low-tech prostheses than for users of bionic prostheses or able-bodied individuals. In sum, despite the mixed results, research based on the SCM shows that the degree of technicity and/or the restored functionality of bionic prostheses influences how others perceive their users in terms of warmth or sociability, and morality (Leach et al., 2007), respectively, and competence. These findings demonstrate that bionic prostheses can profoundly affect the (stereotypic) social perception of their users, as they are perceived differently in terms of competence and morality (Bretschneider et al., 2022; Mandl et al., 2022).

Given that these studies indicate that users of bionic prostheses are seen and treated differently than able-bodied individuals or individuals with a physical disability who do not wear a bionic prosthesis, wearing a bionic prosthesis is likely to affect how their users perceive themselves.

However, the above studies stay mute about how wearing a bionic prosthesis affects central self-evaluations such as competence and sociability. To our knowledge, there is no study investigating how bionic prostheses affect their users' self-image and self-attributions. We are aware of one study investigating the psychological consequences of the traumatic loss of an arm and of the experience of being fitted with a prosthesis afterward from the user's perspective (Saradjian et al., 2008). However, the interviewees in this study did not use bionic prostheses, and the focus was on perceived functional and cosmetic benefits. At the time of the study by Saradjian et al. (2008), bionic (arm) prostheses were not available yet, as the first commercial

bionic hand prosthesis was only launched in the same year. However, even at the time of writing the present manuscript, users of bionic prostheses are very rare.

Taking all these aspects into account, we propose to supplement studies on the psychological consequences of using bionic prostheses by conducting an exploratory qualitative study on the self-perceptions of users of bionic prostheses. In this way, we hope to contribute to build a theory on which self-perceptions and attributions using a bionic prosthesis affects. Our study can also shed some light on whether the SCM is a suitable framework for investigating the effects of using a bionic prosthesis on their users.

Method

Aims

The present study attempts to gain insights into how using a bionic prosthesis influences users' self-perception, including their meta- perception (other-perceptions from the users' perspective) and everyday experiences in social interactions. Additionally, we are interested in how these aspects change when switching from a low-tech or no prosthesis to a bionic one.

Since bionic prostheses are not that widespread or accessible at the time of writing, this study focuses on a small sample of expert users of bionic upper-limb prostheses, as these devices are probably the most common devices available today that embody the above definition of a bionic technology.

Study design

We conducted a qualitative interview study employing a reflexive thematic analysis approach (Braun et al., 2018). Thematic analysis is a variant of qualitative content analysis that offers a „[…] method for identifying, analyzing and reporting patterns (themes) within data. It minimally organizes and describes your data set in (rich) detail“ (Braun & Clarke, 2006, p. 79). After

following the six phases of thematic analysis (Braun et al., 2018), we analyzed the frequency distribution of the topics to structure the themes and identify the most frequent topics from the user's point of view. By doing so and by determining the interrater reliability of the resulting code system, we combined thematic analysis (Braun & Clarke, 2006) with aspects of qualitative content analysis (Mayring, 2015). Taking into account that both methods belong to the qualitative realm and differ only slightly in their basic procedure (Ritchie et al., 2014; Schreier, 2014), we consider it appropriate to combine the strengths of both approaches, thereby somewhat bridging the divide between qualitative and quantitative methods.

Participants

Given that bionic prostheses were rare at the time of the study and given that we rely on a subpopulation that may have experienced trauma and/or stigmatization, participants are not easily available, and recruiting had to be carried out very considerately. Given that we inquired about participants' physical disabilities and asked questions that can potentially trigger negative memories or emotional states, a high level of interpersonal trust was a crucial prerequisite. Consequently, we initially recruited the participants through personal contacts and employed a snowball technique at later recruitment stages, or in other words, we combined purposive convenience sampling with snowball sampling to recruit participants.

Twelve individuals participated in the interviews, but one interview was not suitable for further analysis due to technical problems with the recording. Additionally, we decided to exclude another interview from the final sample, given that the used prosthesis differed substantially from a bionic one. The final sample of ten individuals consisted of four women and six men aged 19–60 years (*Mean* = 37.80, *SD* = 12.69). Limb loss was caused by congenital (n = 7) and traumatic/medical reasons (n = 3). The usage of the current prosthesis model varied

between six weeks and ten years (*Mean* = 4.46, *SD* = 2.85). All ten participants owned bionic forearm prostheses such as the Össur i-limb®, the otto-bock beBionic®, or the Vincent systems evolution® hands. Participants who reported that they stopped using their prosthesis during the interview mainly did so because of physical discomfort or pain caused by the prosthesis. There were no statements indicating self- or meta-perception as a reason for abandoned usage.

Data collection

We conducted semi-structured interviews based on an interview guideline (see Appendix A) that we prepared in advance that included topics we deemed relevant. These topics were derived from the above theoretical considerations referring to the SCM (Fiske et al., 2002) and recent studies on the social perception of bionic prostheses (Bretschneider et al., 2022; Mandl et al., 2022; Meyer & Asbrock, 2018). We were interested in the user's self-perception and in their meta-perceptions regarding the prostheses. According to the SCM, the most fundamental dimensions of social perception are warmth and competence. Therefore, we aimed at analyzing if device users refer to these dimensions or to other attributes. Moreover, different types of prostheses elicit different attributions (Meyer & Asbrock, 2018). Accordingly, we were interested in whether users experience any changes with more technical devices.

Regarding perceptions at the workplace, previous research has shown that competence is perceived as more fundamental than warmth (Abele & Wojciszke, 2014). Moreover, previous research on the role of the fundamental dimensions of warmth and competence on self-perception (Abele & Wojciszke, 2014) inspired our interview questions regarding self-perception. We underscored these theoretical assumptions with the results from an informal expert interview with a user of a bionic prosthesis. Additionally, we included questions about induced feelings/behaviors, desired responses, and an open question to give participants the

possibility to contribute their own thoughts beyond the prompts. We also covered aspects of design and functionality of the prosthesis to gain insights into functionality and potential flaws and to derive implications for future designs. However, those questions and the related themes are not used in the present study.

Our approach guided the interviewees without limiting their answers. Also, it allowed the interviewer to adapt to the participants' narrations by adjusting the order of the questions accordingly. Example questions include: (a) What influence does your current prosthesis have on how other people perceive you? (b) How do people typically react to your current prosthesis in everyday life when they notice it? And (c), What do these reactions trigger in you?

Due to the COVID-19 pandemic and corresponding restrictions during the time of data collection, the first author conducted all interviews online through video conferencing. We used the university's IT infra- structure to ensure the utmost level of data protection. Before the interview, participants received a package containing information about the interview format and aspects of their privacy via e-mail. Participants gave their written informed consent prior to the interview. Nevertheless, due to the interview format and because video and audio data were recorded, we asked for explicit consent again at the beginning of then interview. Interview length varied between 17 min 54 s and 1 h 50 min 53 s, with an average interview time of 48 min 20 s. Data collection took place between May 2020 and April 2021.

Ethical considerations

In accordance with the ethical guidelines of the American Psychological Association (APA; 2017) and the Declaration of Helsinki (World Medical Association [WMA], 2001), we informed the participants about the aim of the study, the content of the interviews, the estimated timeframe, voluntary participation, and data protection. All participants gave their written

informed consent prior to the interview. The local ethics committee (IRB) reviewed and approved the study protocol.

Data analysis

We recorded the video stream of the interviews and, immediately after each interview, extracted the audio from the recording, discarding the video. The first author transcribed these audio recordings after each interview. We used transcription rules (see Appendix B) that are easy to apply but sufficient for differentiation, as suggested by Kuckartz and Rädiker (2019) and Dresing and Pehl (2015). We did not return the transcripts to the participants. The data analysis was carried out by means of thematic analysis using MAXDQA 2020 (VERBI Software, 2019) based on the anonymized transcripts. A deductive-inductive approach was used, and the category system evolved dynamically through the coding process. First, the category system was developed grounded on the theoretical foundations and the interview guideline and then successively expanded and adapted inductively on the basis of the interviews conducted.

To account for the reliability of the coding system in an economic way, we randomly selected 30 % of the material (O'Connor & Joffe, 2020) to calculate interrater reliability. In line with Kuckartz and Rädiker (2019), we calculated Kappa (κ_n) as suggested by Brennan and Prediger (1981) instead of Cohen's κ to account for the methodological shortcomings of the latter. Despite being calculated somewhat differently, κ_n can be used and interpreted by the same means as Cohen's κ (Bornmann & Daniel, 2009; von Eye & von Eye, 2005). The interrater reliability $\kappa_n = 0.64$ indicates substantial agreement or good reliability, respectively (Landis & Koch, 1977). We applied the final category system to all transcripts. Next to the first author, an independent external consultant, who is a psychologist and specializes in qualitative analysis, analyzed and coded all transcripts to increase intersubjective agreement. Any remaining

disagreements were discussed within the team to reach consensus by building a new theme or renaming themes.

We stopped coding after all interviews were coded and all relevant passages were assigned to an appropriate category. Finally, based on the frequency distribution of the themes, we identified the most frequent topics from the user's perspective.

Results

The thematic analysis revealed five main themes: (1) general aspects of prosthesis use, (2) encounters, (3) repeated experiences with others, (4) personal experiences and views, and (5) other experiences regarding the use of the prosthesis (which is not further analyzed in this study). See Table 1 for an overview of the respective themes and subthemes. A full thematic overview and visual representations of the connections be- tween all themes and sub-themes can be found in Appendix C.

Theme 1: general aspects of prosthesis use

This main theme covered several subthemes associated with prosthetic use ranging from the wearing period via the type of prosthesis worn to changes in everyday experiences. These changes or the potential impact on users' everyday experiences, respectively, are the analytical focus within this theme. In this study, we analyzed the changes associated with the current prosthesis as the only subtopic.

Changes associated with the current prosthesis

Within this subtheme, interviewees mentioned several changes caused by the bionic prosthesis, including regaining capabilities, bene- fits in everyday activities like driving, physical relief, and a more natural pose during specific movements.

> At that time, I was also active in project management, and I was in charge of a municipal construction project as a deputy project manager. I was also sometimes on the construction site, for example, to sign at an approval. With my [previous] habitus prosthesis, I always had to look somehow for where I could go and somehow sup- port this and then make the signature. And then I received my i-Limb pulse, and then it was just possible. (I3)

Nevertheless, some interviewees also mentioned feelings of insecurity, especially while adapting to the new prosthesis, due to the design of the prosthesis.

> Um, and I have that, in any case, more certainly with the VINCENTevolution ® prosthesis because that just stands out. With the other one, I think people often didn't notice that (unclear) and thought I somehow had a bandage or something in the place where it goes over to the arm. So, uh, exactly. That also makes me feel insecure, partly (…). (I4)

Overall, the participants mainly mentioned positive changes, at least after a period of adaptation, and experienced themselves as more competent, including an increased perception of self-efficacy.

Theme 2: encounters

This category covers both positive and negative first encounters. For each of these two subthemes, the analysis identified further subthemes. For positive first encounters, these covered general aspects of social situations, technical fascination by interaction partners, and interest. Experiences of negative first encounters covered the subtopics of a perceived lack of understanding, pity, disgust, and hostility.

Positive first encounters

General aspects. This subtheme covers interview statements associated with positive first encounters that do not fall into the sub- sequent more specific subcategories. Some

participants reported that positive reactions toward their prosthesis dominate their first encounters.

> To answer your question, I was always treated extremely nice. So really very courteous and - had really kind of, clearly until I realized that, some time had to pass. (I2)

Technical fascination. The interviewees mentioned that technical fascination is positively linked to reactions from others. Especially the admiration of technical progress and the corresponding functionality is mentioned as a prerequisite for positive reactions.

> (...) just had the wallet in the prosthesis, and then he asked "May I ask what's up with your hand?" and then I gave him the short version. And he was like, "Wow, you can move this thing" and I was like, "Yeah" – "Wow, cool, Terminator-like, what's possible these days, mega cool"! (I1)

Interest. The users described that they experience a strong interest in their device that leads to inspiring conversations about the device and their impairment or the regained capabilities, respectively, without being pitiful.

> (...) I recently had another experience where someone, um, came up to me and said, "Hey" and that happens very often, "Hey, I didn't even notice that when we worked together all day; that's awesome, you don't even notice that because you move so naturally and I only noticed that because you were holding something" or because of a movement like that. And then most of the time, people are like, "Wow, you're doing great, and that's awesome." (I10)

Extending the positive first encounter condition, bionic prostheses, due to their technical appearance and potential to restore significant capabilities, seem to influence the first impression

that users elicit to- ward a more positive connotation. Also, users mentioned admiration for their capacities, which can be interpreted as an indicator of gaining ascribed competence.

Negative first encounters

Despite the positive experiences described above, users also experienced adverse reactions from others, mainly caused by their impairment and not necessarily linked to the prosthesis. Overall, we identified four relevant subthemes.

Lack of understanding. Users mentioned irritating and bothering reactions from others which they predominantly attribute to a lack of understanding of their situation.

> (…) in the supermarket, my wallet fell down because I had moved my hand the wrong way. Behind me, the people at the checkout also groaned and looked a bit askant, yes. Until you made it clear that you can't do much about it or that it just happens that way. Yes, but that is then so directly attributed to the disability, and yes, partly it is annoying, but you have to be above it, then it works. (I6)

Pity. The interviewees describe that they induce a feeling of pity in others due to their impairment, which they perceive as an attribution of low competence and experience in a negative way.

> Yes, that actually still happens often because before, I didn't have this hand prosthesis, and I was one-handed and did everything with my left hand (laughs); no, joking aside, of course, there was always such a pitying look. And a bit of "The poor boy" or later, "This poor man, he has no hand; he surely needs a third person (unclear) to tie his shoes or zipper up his jacket". (I2)

These experiences were primarily caused by the impairment before the participants used a bionic prosthesis. Although using a prosthesis seems to mitigate these issues, they still occur.

Disgust/rejection. The participants also mentioned situations in which they were confronted with signs of disgust and rejectionist behavior caused by their prosthesis or impairment. However, although most participants reported reactions toward their prosthesis, we were unable to distinguish whether such reactions were triggered by the prosthesis or by the impairment as such. This may be caused by the link between being disabled and wearing a prosthesis.

> There were some girls (…), how old might they have been, maybe something between 15 and 18. Um (...), and I didn't even realize it at first because I had headphones on, but one of them saw the hand and used it as an opportunity to say to her friends, "Hey, look, what's he got there" - like that. And that had extremely negative connotations. It was really like, "ew". And it really annoyed me in the situation; they were also quite loud about it. (I1)

Hostility. Some users described experiences of discrimination or behavior that they interpret as mainly hostile caused by their impairment.

> Yes, yes, being judged behind one's back. Most of the time, it is group behavior by others, you could say, where people really get into it. What you cannot do and what wouldn't be possible, and how shitty that would be. It goes in that direction. (I5)

Summarizing the encounter theme, answers show that positive (15 codings) and negative experiences and ascriptions (15 codings) during the first encounters are equally common. However, almost all positive first encounters are connected to wearing the bionic prosthesis, its appearance, and its functionality. In other words, most positive aspects are linked to the prosthesis and its technicity. On the contrary, negative experiences were almost exclusively linked to situations in which the prosthesis was not worn or not visible to bystanders or interaction partners.

These findings indicate that bionic prostheses can have a considerable impact on how others perceive users during first encounters and might help to form positive first impressions.

Theme 3: repeated experiences with others

This category ranges from others' reactions toward bionic users to the desired responses (i.e., the way in which users desire how others react to them). In contrast to the previous theme, this category focuses on mid- to long-term experiences in social interactions, instead of coincidental first encounters. The analyzed subthemes within this theme covered the influence of the prosthesis on other-perception, reactions to the prosthesis, the impact of wearing the bionic prosthesis in work contexts, and the associated perspective of colleagues and supervisors.

Influence of the prosthesis on others' perception

General aspects. This subtheme covers statements associated with repeated encounters with others that do not fall into the subsequent more specific subcategories. On a general level, the interviewees mentioned that the way how others perceive them has fundamentally changed for the better.

> The encounters don't end with "The woman only has one hand" but "Wow, that's the technology today." You are no longer "Oh, the poor person," but "Wow, she can handle it". (I3)

Participants mentioned that they are seen as more equal, and that others' perception changed from pitiful and less competent to an ascription of competence, for instance, because they can handle such a technical device.

Clear indicator. The participants described a signaling function of their prosthesis due to its technicity, which makes it obvious that they are wearing a prosthesis.

> If you wear a hand that's obviously not real, you're also signaling to them that it's okay for you. Um, while if you wear one that pretends to be real, it's more of a signal of "I don't want to be talked to about it". (I4)

Users evaluated this signaling function positively because it reduces staring, making it easier for others to seek out contact without speculation.

Reactions to prosthesis

This is the umbrella category for the following specific common reactions.

Patronizing. This category covers aspects of experienced patronizing behavior mainly induced by an ascribed handicap or incompetence. Participants experienced these ascriptions or behaviors mainly as adverse and disrespectful.

> When you're shopping, and you're standing at the checkout, the cart is full, and someone says, "Can I help you?" and you say, "No, thanks, I'll be happy to do it on my own" – "I just wanted to help you" (gets loud) (laughs). (…) it was an older woman who asked me, and then she somehow couldn't handle it, that I refused. (I8)

Curiosity. The participants mentioned that curiosity mainly causes interest in their person, their prosthesis, and its technical capabilities.

> (…) ([T]here are many parents who also say, "Now I have to talk to you; my son told me that you are now wearing a prosthesis, and now I have observed you from a distance" - there are many, yes - it is simply the curiosity that prevails. And the interest. Sometimes the interest in the technology comes after it; there, you always notice the fine-tuning; it is also "How is it to be on the move with only one hand?". (I8)

Overall, this curiosity is seen as a positive aspect of using the bionic prosthesis. It makes it easier for users to talk about their situation without feeling reduced to their impairment.

Irritation. Users reported that others are irritated by the bionic prosthesis and its technical appearance because they are unfamiliar with such devices. Some users experience this as an understandable reaction and appraise it as neutral, whereas others perceive it as unpleasant.

> Yes, it's just like that; you can't blame people. I've known it all my life and people who have never seen it before, well, maybe you look, you don't expect it to be something like that. And (...) maybe that's the look when you see things for the first time, and you can't really classify them, or you feel unease, yes. It happens in any case, yes, in any case, yes. (I5)

Impact on the working context

Limitations. A few participants described limitations at work, but these were mainly linked to a need for finer motor skills when typing or handling small parts.

> Sometimes I think "Well, if you could type with ten fingers, that would be faster" and (…) on average, if you were five seconds faster per e-mail and extrapolated to 100 e-mails a day, that's already a cup of coffee that you (unclear) could, probably. But to be honest, I'm also pretty fast with five fingers, and that's the only thing where I sometimes have the feeling that I'm experiencing a functional restriction (unclear) due to my handicap. Then, when it comes to carrying any stuff, really trivial. (I1)

No impact. Overall, most users clearly stated that they do not experience any limitations while engaging in activities of daily living with their bionic prosthesis.

> I don't think it's that relevant for me at work. I did it for nine years without it [i.e., the prosthesis] before, and that worked well, too. That's not what it's about when you're working on the PC. In my opinion. So, compared to the others, I'm an absolutely average person. (I5)

Regarding the work context, the prosthesis has no impact on users' perceived capability in most situations except for some finer motor tasks. Moreover, participants also describe that they are seen as equal co-workers and experience admiration for their performance despite their impairment. We interpret this as an indication for gaining ascribed competence and for the inclusive potential of bionic prostheses at work. Nevertheless, one must note that most of our participants work in the service sector; these experiences are likely to be different in blue-collar work settings.

Treatment by colleagues and supervisors

Surprise. Some participants described surprised reactions from their colleagues or supervisors.

> And there was, no, there were only men. Except me. And then also blond, small, and only one-handed, oh my god (laughs). So, and then I was at the construction site like, "Yes, Mrs. (name), we need a signature now," and then I just - then I stood there like this (…) and gave the signature, like everyone does, standing up (…) And then everyone stopped talking (…) (laughs), looked at me like this (…) Well, I looked back and thought, "Guys, I can do that too now." (I3)

Overall, this surprise is not negatively connotated. Some users experience this surprised reaction as more or less neutral because they interpret it as an understandable irritation. However, more interestingly, other users describe the surprised reaction as a result of the regained capabilities and the fact that they can perform like able-bodied people with the prosthesis. This is perceived as a gain in competence, and they interpret the surprise of others as admiration for their own skills. We interpret this once more as an indicator of a gain in competence in the other-perception caused by using a bionic prosthesis.

Acceptance. A majority of users reported that they are not treated as special by their colleagues and supervisors.

> Well, I would generally say that I'm not treated particularly well or anything like that. So, they ask here and there if I can do something or not, if they should help me somehow, but (...). Of course, I don't have the view of a person without a disability. (I9)

The interviewees generally mentioned that they feel accepted and treated equally. After a period of adaptation, they also feel entirely accepted by new colleagues unfamiliar with physical disabilities and the use of bionic prostheses. We also see this as a sign for the inclusive potential of bionics such that their users are seen as competent as able-bodied individuals.

Summing up the repeated experience theme, positive experiences (30 codings) outweigh the potentially more negative aspects (17 codings) of using a bionic prosthesis. These findings indicate the positive effects of bionic prostheses on several aspects of interpersonal perception and demonstrate the inclusive potential of such devices in everyday life. Especially in the working environment, where users are seen as equally competent as their able-bodied colleagues and are admired for their capabilities, the inclusive potential and the effect of bionic prostheses on ascribed competence seem quite obvious.

Theme 4: personal experiences and views

This category subsumes the influence of using a prosthesis on self-perception and the perception of the need for assistance and offered assistance as analytical foci of this study. However, other personal experiences, such as physical consequences of prosthetic use or how users deal with their disability, are included in this category, which is beyond the scope of this study. Consequently, these additional themes are not included in the current study's results. For a comprehensive overview see Appendix C.

Prosthesis and self-perception

> Yes, of course. So that's just a lot (...) so you get just self-confidence, yes, if that just no longer seems so (...) self-made and embarrassing and repulsive, but (...) high-quality and technically. That's also something; ultimately, I think you can compare the influence on self-worth with someone who evaluates his self-worth because he buys a cool car. And thereby, it's just a self-worth improvement (unclear). (I1)

Perception of the need for assistance and offered assistance

> This encroachment often. That people think they're doing some- thing good for me, and then I stand there and think. With that, you're strongly confronted again with the fact that you only have one hand. (I8)

Resuming theme four, the participants described a significant in- crease in self-esteem, self-confidence, and independence. So, users of bionic prostheses do experience themselves as independent, and there is no need for assistance. Nevertheless, some experience offered help as attentive behavior that could be declined. On the other hand, some experience unwanted help as encroaching and discriminatory.

Table 1

Themes and subthemes.

Themes and subthemes			Definition	Example	Frequency
General aspects of the prosthesis	Changes with current prosthesis		Users describe a variety of often very positive changes in everyday life as a result of wearing the current prosthesis. The perception of others is partly different, but many in particular experience the functionality in everyday life as significantly better.	"I used to have so much fun with new things, 'Hey, I can open a banana with two hands'. I used to be able to open it too, but I used to do it with my mouth. And now I can just sit up straight and I can open the banana (…) Those were really, really great moments where I (…) never missed reaching, but when you have the possibility to reach with two hands and (…) then you experience your daily life in a completely new way. And that has brought me incredibly forward (…)." (I 3)	20
Encounters	Positive first encounters	General aspects	Participants describe that others generally respond positively to the prosthesis.	"I: So very briefly, in everyday events, the positive tends to predominate in the interaction or rather… B: Yes, yes, clearly. Yes, that is very nice." (I1)	2
		Technical fascination	Users describe that many express or show a technical fascination for the prosthesis and admire	"So, I would say curiosity, but then also curiosity about technology. Many people then say, 'Wow, we didn't even know' or 'I didn't even know that such a thing already existed and	8

Themes and subthemes		Definition	Example	Frequency
		the technical progress.	that the development is so far advanced'. Those are actually common reactions. Otherwise (…) they all think it's quite good that something like this exists. And, yes, these are the comments that always come up. Most of the time." (I 6)	
	Interest	Users describe that they often receive interested inquiries from others or get into conversation with others through their interest.	"It actually happens more often that someone comes to meet me or I'm somehow at an appointment or something and before the people talk to me, they first look at my hand the whole time. And then they say, 'Yes, excuse me, I'm a bit puzzled or I have to ask what exactly you have there' and so on. So, they are all very nice and open-minded and then I explain it to them. And that's always very nice. So, these are positive (…) encounters for me." (I 6)	5
Negative first encounters	Lack of understanding	The users describe that they are sometimes met with incomprehension from others and that these reactions are perceived as annoying.	"I couldn't establish any resonance because never felt like 'I want to prove to you how I can do it.' (…) However, people who have two hands always think I want to prove something when I do things by myself." (I8)	4

Themes and subthemes		Definition	Example	Frequency
	Pity	Users describe experiencing pitying looks or expressions of sympathy because of their impairment.	"(…) And there I had rather, so at least from my perception, that seemed to come rather so, the looks of the people at the missing limb and rather than so in the form of pity or, I don't know how I should describe it, rather so negatively connoted. 'Oh you poor thing.'" (I 12).	4
	Disgust / Rejection	Users describe situations in which they have experienced negative looks or comments from others because of their impairment or their prosthesis.	"And I mean looks can also be very hurtful. Everyone knows that; it doesn't have to be a word, just a look. And (.) sometimes such a look, which sounds a bit harsh now, is almost filled with disgust. And you notice that you notice that (…)." (I2)	4
	Hostility	Users describe experiencing hostility or discrimination from others because of their impairment.	"So, the most negative experience for me in that sense was that I had to write an exam. (…) I wrote longer, and then (…), when I handed in, then the professor came to me and said to me, 'So if it had it my way, (…) I would not have given you [the time compensation]'. (…) he has quasi said you-yes, no, your disability does not count." (I 12)	3

Themes and subthemes			Definition	Example	Frequency
Repeated experiences with others	Influence of prosthetics on other-perception	General aspects	The users describe that the perception of others is changed by wearing the prosthesis, e.g. that people react more positively or that they are recognized more overall.	"And when I got the prosthesis, it was more like that, so of course the gaze still wandered downwards, but then it had more of a positive connotation because then the question was more like 'Hey, that looks cool!' (…) And then, yes, the image was a different one." (I 12)	6
		Clear indicator	The users describe that wearing the prosthesis is a clear sign for the other person and thus speculations and assumptions of others can be reduced.	"And by being open with it and wearing it openly, you also make it easier for the other person to get in touch than if I hide it and the biggest thing for me is that you don't see it. (…)" (I 3)	7
	Reactions to the prosthesis	Patronizing	The users experience being confronted with patronizing due to their impairment.	"So, it's more annoying for me when (..) or someone says, 'Oh, I'll take that off your hands and you probably can't do that at all' and 'Can you tie your shoes?'" (I10)	4
		Curiosity	Users experience positive interest or curiosity, especially regarding their prostheses.	"Well, I think a positive connotation of interest or curiosity is actually a good reaction. Sometimes a little less of it. On the one hand, I enjoy it very much, because I'm somehow also (...) an extroverted person who also enjoys	5

Themes and subthemes		Definition	Example	Frequency
			being the center of attention, like that." (I 1)	
	Irritation	Users experience that other people stare at them, observe them, or look at them several times. Some experience this as unpleasant, others as neutral.	"Yes, so what bothers me are the looks. So just looking and not saying anything." (I 9)	11
Impact on the working context	Limitation	Participants experience themselves as well-positioned for their jobs, but also repeatedly experience minor limitations, such as dexterity.	"I'm actually in a good position. (…) I get along well with my prosthesis, but still requires a certain dexterity with two hands, which I cannot provide to the extent. But that's not necessarily a problem for me." (I 12)	2
	No impact	Participants describe that they do not experience any significant limitations in their daily work due to their impairment or prosthesis.	"So, I would actually say that this is quite normal. So, the disability or prosthesis doesn't play a role at all. It is so (unclear) that I am actually often praised for the fact that I, despite my disability, do all the tasks quasi quite normally and get along with it very well. I had that in school several times and also in my company I was often praised for that, (…) despite the impairment, that you don't notice that	7

Themes and subthemes			Definition	Example	Frequency
				at all, and that I would be quasi a completely normal employee or classmate and that would not be a problem at all." (I 6)	
	Handling by colleagues and supervisors	Surprise	Some users report surprised reactions from their colleagues.	"Some (..) you can see the fright already a little bit, so never seen before (…) or I don't know, uneasiness people get." (I 5)	2
		Acceptance		"Yes, yes, absolutely, you notice that at the beginning- Every year new people come and yes, at the beginning it's unfamiliar. But they already make the effort that they (…) accept you. And then yes, after a few weeks at the latest, it's no longer a problem, then I don't have any problem with it." (I 5)	7
Personal experiences and views	Prosthesis and self-perception		Many users describe that wearing the prosthesis has a positive influence on their self-perception and strengthens their self-confidence. If the prosthesis is still new to the user, however, additional insecurity is also described.	"And with the prosthesis, it has become something completely different. You also like to go out in a T-shirt to show off the prosthesis more or less. (…) I don't have to hide my arm like I used to. I just go out normally and people either look or they don't, but I don't care anymore. So, in any case it's a very big positive influence." (I 6)	14

Themes and subthemes	Definition	Example	Frequency
Perception of the own need for assistance and offered assistance	Users express that offers of help from others are responded to in different ways - some perceive this as attentive, others as discriminatory.	"So, I had very positive experiences and also, for example, in the supermarket, when shopping, it often happened where I was out without the hand (…), that the saleswoman or the seller approached me at the checkout and said, 'Can I help you pack?' And of course, I often said no and thanked them, I thought that was very thoughtful. (…) I have a good colleague, he is three years younger than me, he had to have his whole left arm amputated due to an accident. (…) And he finds, for example, the exact same situation in the supermarket, when someone asks him (…) to pack, he finds that very discriminatory." (I 2)	3

To summarize the results, the interviews indicate that, when using no prosthesis or low-tech ones in the past, participants describe reactions from others that they perceive primarily as patronizing, some- times encroaching behaviors. Users interpret these behaviors as an implicit ascription of incompetence. This perceived tendency changes when using a bionic prosthesis. Users describe that they perceive being seen more positively by others when using a bionic device. Users also describe feeling more competent and experiencing higher levels of self-efficacy due to regained capabilities when using a bionic prosthesis. Nevertheless, participants also reported that they still experience stigmatization and inappropriate behavior like being stared at, patronizing, sometimes encroaching behavior, or unwanted help.

Discussion

The study's primary focus on the experiences associated with participants' current prostheses limited our ability to explore the influence of the duration of prosthesis use on reported hindrances. Despite the diversity in causation of amputations, the findings suggest that these differences did not significantly impact participants' current experiences, as highlighted in our analysis. However, it is important to acknowledge that participants did share various life experiences closely linked to the causes of their impairments, primarily discussed in theme 1, which falls outside the scope of the present study.

Nevertheless, in sum, the findings show that using a bionic prosthesis profoundly impacts how users perceive themselves and how they perceive others' behaviors toward them. All of our interview participants had prior experience of living without a bionic prosthesis. They reported stigmatizations (e.g., pity, disgust) that fit the predictions of the SCM for people with physical disabilities (Fiske et al., 2007). Switching to the bionic device was associated with perceiving different behaviors in others, some of which can be summarized as positively connotated

interest. These reactions seemed to be mirrored in increased levels of self- efficacy and sometimes even pride. In this way, the technology seemed to have a noticeable psychological effect on their users in the sense that wearing the device offsets the stigma that is associated with disability, both for the behaviors of others and in terms of corresponding self- perceptions. In short, these experiences support that a bionic prosthesis is able to offset stereotyping behaviors and reduce self- stigmatization and self-stereotyping.

While these perceptions and self-attributions are in stark contrast to the stereotype content that the SCM assumes for people with disabilities, they are in line with earlier findings (Meyer & Asbrock, 2018) showing that bionic prostheses are able to offset disability-related stigmatization. However, the interview results paint a more nuanced and complex picture: wearing a bionic prosthesis offsets some, but not all, of the stigmatizing behavior our participants reported. In some situations, interviewees still reported stigmatizing and patronizing behaviors by others. Therefore, in sum, it seems that several identities exist at the same time: On the one hand side, users are cyborgs in the positive sense of the word who experience pride in their bionic prosthesis, because it bestows them with a sense of competence that stands in stark contrast to the stigma they experienced before receiving the bionic device. How- ever, at the same time, they still experience discrimination and corresponding frustrations that are associated with the stigma of a physical disability. Therefore, the bionic device not fully replaces the stigmatized identity of the disabled individual, but supplements it with a simultaneous dual identity of a competent-and-warm cyborg.

Managing a dual identity can, however, be challenging, as different identities are likely to become salient in different contexts (González & Brown, 2006). Therefore, despite the potential positive psychological benefits of a bionic prosthesis, users must cope with switching between

the competent identity bestowed by their prosthesis, and the stigma associated with their disability, especially if they are not wearing the prosthesis or if it is not visible. Therefore, putting on the bionic pros- thesis is also likely to make a different identity salient.

Of note, interviewees reported not only short-term but also lasting positive long-term consequences of wearing a bionic prosthesis. The changes in other-perception do not seem to wear off after repeated contact, even with close peers such as work colleagues. This finding speaks to the potential stability of the changes in self-evaluations brought about by wearing a bionic prosthesis.

In sum, the findings indicate a dual identity of our interviewees, with situational properties governing identity salience. For the work context, bionic prostheses appear to foster the integration of our interviewees, partly because of elevated levels of ascribed competence (cf. Vornholt et al., 2013). Based on prior studies and our theoretical framework, we propose that our results can also speak to the effects of other embodied bionic technologies like lower-limb prostheses. However, given that bionic legs are larger and given their different functionality in comparison to arms, further research on this topic is needed. The results might also indicate a potential use of bionic devices for restoring or augmenting user capabilities in the workplace and future work settings.

Limitations

Our study is not without limitations. Specifically, our sample consisted only of German-speaking individuals who use upper limb prostheses and was gathered by convenience sampling at the first stages and combined with a snowball technique later on. Consequently, the results may not represent a larger population of bionic prostheses users and do not generalize across cultural contexts. Secondly, gathered opinions, experiences, and interpretations are limited due to

personal experience and knowledge. Furthermore, despite methodological caution and good interrater reliability, results may unintentionally be biased by the re-searchers during data collection or categorization. These limitations are typical for qualitative studies; the results are neither fully representative nor generalizable and are not simply transferable to different cultural contexts. Finally, it is worth noting that the decision not to subdivide the first theme into specific subcategories, such as daily activities and personal feelings, can be considered a limitation of this study, as it may have obscured more nuanced insights within this overarching theme.

Conclusion

Despite the limitations mentioned above and despite being exploratory, our study provides first insights into how users of bionic pros- theses perceive themselves, into their meta-perception of being seen by others, and into their experiences in daily life. The usage of bionic prostheses has a profound impact on social perception, stereotypes, and interpersonal perceptions, such that users of bionic prostheses perceive being evaluated more positively by others. Additionally, our findings indicate the inclusive potential of bionic prostheses in work settings. In line with these findings, users perceive themselves as more competent and physically capable. In contrast, using bionic prostheses does not mitigate all (adverse) effects of stereotyping, and might lead to device- specific negative ascriptions at higher levels of merging humans with technology (see Meyer & Asbrock, 2018).

Nevertheless, these results are limited to upper limb prostheses and come at an early stage while bionic devices are not widespread, and their proliferation is still ongoing.

While we can show the inclusive potential of bionic prostheses, introducing such technologies, especially augmenting ones, in future work contexts might have unintended social consequences that must be accounted for. We expect that augmenting devices will also trigger

the here reported processes of social perception and stereotyping with positive and negative outcomes, as already pointed out by Gilotta et al. (2019) and Siedl and Mara (2021). For example, wearing an exoskeleton could also lead to stigmatization in the workplace, as it may appear that workers depend on their support. Therefore, further research is needed to account for possible unwanted side effects and to use the potential benefits of such technologies simultaneously. While this study focused on restorative bionic devices, we will explicitly address devices for augmenting user capabilities and focus on more work-related applications, such as exoskeletons, in upcoming studies to broaden the knowledge about the effects of bionic embodied digital technologies usage.

CRediT authorship contribution statement

MB: Conceptualization, Methodology, Project Administration, Investigation, Formal analysis, Writing – original manuscript. BM: Conceptualization, Methodology, Writing – review & editing, Supervi- sion FA: Conceptualization, Methodology, Writing – review & editing.

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Declaration of competing interest

No conflict of interest exists.

Data availability

The data that has been used is confidential.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.actpsy.2023.104085

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III. APPENDIX

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Bretschneider, M., Drössler, S., Magister, S., Seidler, A., Engel, T., Schmidt, S., Vitera, J., Lemanski, S., & Muehlan, H. (2019, March 20-22). *Arbeitsbedingungen in der „Industrie 4.0“ und gesundheitsbezogene Implikationen – Stand der Forschung und arbeitsmedizinische Relevanz.* 59. Wissenschaftliche Jahrestagung der Deutschen Gesellschaft für Arbeits- und Umweltmedizin (DGAUM), Erfurt.

Bretschneider, M., Drössler, S., Magister, S., Zeiser, M., Kämpf, D. & Seidler, A. (2019, March 20-22). *Psychische Belastungen als besondere Herausforderung der Digitalisierung - Implikationen für die arbeitsmedizinische Praxis. Ergebnisse des Projektes GAP.* 59. Wissenschaftliche Jahrestagung der Deutschen Gesellschaft für Arbeits- und Umweltmedizin (DGAUM), Erfurt.

Bretschneider, M., Drössler, S., Magister S., Zeiser, M., Kämpf, D.; Seidler, A. (2019, February 27-March 01). *Digitalisierung und Psyche - Rahmenbedingungen für eine gesunde Arbeitswelt. Ergebnisse des Projektes GAP*. 65. Frühjahrskongress der Gesellschaft für Arbeitswissenschaft e.V., Dresden.

Bretschneider, M., Drössler, S., Kämpf, D., Magister, S., Zeiser, M., & Seidler, A. (2018, September 12-14). *Psychische Belastungen als besondere Herausforderung im technologischen Wandel.* 54. Jahrestagung der Deutschen Gesellschaft für Sozialmedizin und Prävention (DGSMP), Dresden.

Bretschneider, M., Drössler, S., Magister, S., Seidler, A., Engel, T., Schmidt, S., Vitera, J., Lemanski, S, & Muehlan, H. (2018, September 12-14). *Digitalisierung, Industrie 4.0 und Gesundheit – ein Literaturreview zur empirischen Befundlage.* 54. Jahrestagung der Deutschen Gesellschaft für Sozialmedizin und Prävention (DGSMP). Dresden.

Invited Talks

Bretschneider, M. (2022, January 09). *Arbeit im Homeoffice und (psychische) Gesundheit – Chancen, Risiken & Empfehlungen.* ver.di Landesverband Sachsen West-Ost-Süd (SWOS), Dresden.

Bretschneider, M. (2020, January 29). *Digitalisierung und Arbeit – Chancen, Risiken und Konsequenzen.* ver.di Landesverband Sachsen West-Ost-Süd (SWOS), Dresden.

Engel, T.; **Bretschneider, M.** (2019, November 20). *Gesunde Arbeit - ein erreichbares Ziel in der digitalen Transformation?* Tag der gesunden Arbeit. Ernst-Abbe-Hochschule, Jena.

Bretschneider, M. (2019, October 11). *Mobile Arbeit – Chancen und Risiken*. GBR-AGU der Volkswagen Sachsen GmbH, Chemnitz.

Bretschneider, M. (2019, May 23). *Psychische Belastungen als besondere Herausforderung im technologischen Wandel.* Betriebs- und Personalrätekonferenz ver.di Thüringen, Erfurt.

Bretschneider, M., Engel, T., Zeiser, M. (2019, February 06). *Digitalisierung, Arbeit 4.0 und Gesundheit – Bedeutung für die betriebliche Praxis.* Dresdner Treffpunkt. Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, Dresden.

Bretschneider, M.; Melzer, M. (2018, November 26). *Der Mensch in der digitalen Arbeitswelt.* workshop forum.sachsen.digital. Sächsisches Ministerium für Wirtschaft, Arbeit und Verkehr, Chemnitz.

Bretschneider, M. (2018, June 13): *Anforderungen an einen Arbeits- und Gesundheitsschutz 4.0.* Werkstatt Wirtschaft Arbeit des Sächsischen Ministeriums für Wirtschaft, Arbeit und Verkehr, Bautzen.

Curriculum vitae

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born November 7th, 1980 in Leipzig

Academic qualification

since 04/2020	**Chemnitz University of Technology** Desired: Doctoral degree (Doctor rerum naturalium) Title: Social Perception of Human Augmentation Technologies – Implications and Outlook Supervisors: Prof. Dr. Bertolt Meyer, Prof. Dr. Frank Asbrock
since 2017	**University of Applied Health Sciences** Desired: Master of Science in Work and Organizational Psychology
2011 - 2014	**Friedrich Schiller University Jena** Master of Arts in Sociology Grade: 1.4
2007 - 2011	**University of Marburg** Bachelor of Arts in Social Sciences, Peace and Conflict Studies, and Psychology Grade: 1.7

Work experience

since 04/2020	**Professorship of Work, Organizational, and Economic Psychology; Professorship of Social Psychology, Chemnitz University of Technology** Research and Teaching Associate
05/2020 - 12/2021	**Institute and Policlinic of Occupational and Social Medicine, Faculty of Medicine, Dresden University of Technology** Research and Teaching Associate
10/2020 – 03/2021	**Section Occupational Medicine, Faculty of Medicine, Martin-Luther-University Halle-Wittenberg** Research Associate

06/2019 - 02/2020	**Health Department, Volkswagen Sachsen GmbH** Associate
01/2018 - 09/2020	**Institute and Policlinic of Occupational and Social Medicine, Faculty of Medicine, Dresden University of Technology** Research and Teaching Associate
01/2017 - 03/ 2017	**Friedrich Schiller University, Jena** Service Contract - Survey Realization & Evaluation
01/2015 - 03/2015	**Friedrich Schiller University, Jena** Service Contract - Survey Realization & Evaluation

Trainings / Certifications

2019	**Systemkonzept GmbH** Occupational Safety Specialist
2018	**University of Applied Health Sciences** Stressmanagement-Trainer
2018	**International Critical Incident Stress Foundation, Inc.** Assisting Individuals in Crisis & Group Crisis Intervention
2017	**artop – Institute at the Humboldt University of Berlin** Communicational and Behavioral Trainer

Professional Activities

Ad-hoc Reviewer	Acta Psychologica, Gruppe. Interaktion. Organisation. Zeitschrift für angewandte Organisationspsychologie, International Psychogeriatrics, Journal of Occupational and Environmental Medicine, Journal of Public Health, Prävention und Gesundheitsförderung
Memberships	Berufsverband Deutscher Soziologinnen und Soziologen (BDS), Deutsche Gesellschaft für Arbeits- und Umweltmedizin (DGAUM), Deutsche Gesellschaft für Medizinische Soziologie (DGMS), Deutsche Gesellschaft für Soziologie (DGS), Deutsche Gesellschaft für Psychologie (DGPs), European Association of Work and Organizational Psychology (EAWOP), European Public Health Association (EUPHA)

Eidesstattliche Erklärung

Name: Bretschneider

Vornamen: Johannes Maximilian

geboren am: 07.11.1980

Ich erkläre an Eides statt, gegenüber der Technischen Universität Chemnitz, dass ich die vorliegende Dissertation selbstständig und ohne Benutzung anderer als der angegebenen Quellen und Hilfsmittel angefertigt habe.

Die vorliegende Arbeit ist frei von Plagiaten. Alle Ausführungen, die wörtlich oder inhaltlich aus anderen Schriften entnommen sind, habe ich als solche kenntlich gemacht. Ich bin mit einer elektronischen Überprüfung auf etwaige Plagiate hin einverstanden.

Diese Arbeit wurde in gleicher oder ähnlicher Form noch bei keinem anderen Prüfer als Prüfungsleistung eingereicht.

Chemnitz, den 27.03.2024

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