

The impact of a customized aesthetic prosthetic leg cover on social interaction cues and attitudes in the general UK population: Two experimental studies

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Abstract

Objectives: To explore the impact of an aesthetic prosthetic leg cover on attitudes toward individuals with lower-limb amputation and associated social interaction cues among the general UK population.

Study Design: Two novel experimental methodologies.

Methods: In study 1, participants ($n = 188$) viewed 1 of 3 images of an individual: (1) wearing a traditional stem prosthetic, (2) wearing an aesthetic leg cover, or (3) as a nonamputee. They then completed an attitude scale and rated the personality of the individual using the 10-item Big Five Inventory. Study 2 ($n = 31$) used eye tracking and facial expression software to explore gaze and facial arousal when viewing 1 of 9 manipulated videos of the same individual talking about 3 different scenarios.

Results: In study 1, the aesthetic leg cover led to significantly higher ratings of agreeableness than stem and nonamputee images and significantly higher ratings of extraversion than the nonamputee image. Attitudes toward an individual with a prosthesis did not significantly differ depending on which image they viewed and were generally positive. In study 2, all participants focused mainly on the individual's face regardless of scenario topic or leg condition, although participants focused more around the leg cover in more active contexts.

Conclusions: Customized aesthetic leg covers may help individuals living with amputation to be perceived more positively in social situations. These experimental methodologies could be extended to explore the differential impact of context, functionality, and activity of specific types of customized aesthetic prosthetics and could help inform shared decision-making processes in clinical settings.

Keywords

customized prosthetics, limb covers, aesthetic covers, psychosocial impact, social interaction, prosthesis embodiment

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Introduction

The psychosocial impact of limb loss and subsequent adaptation to living with a prosthesis is profound. Clinical and scientific developments mean that the physical challenges of lower-limb amputation and living with a prosthesis are increasingly being addressed through a range of medical, clinical, and assistive technology services that can improve issues with mobility, balance, pain, and discomfort. Despite these developments, high rates of anxiety and depression remain a major factor in the first few years after amputation, and both short- and longer-term distress are associated with self-reported social discomfort, perceived social stigma, and body image concerns.¹⁻⁴ This self-stigma and social discomfort often lead to further restriction of already limited activities, leading to increased social isolation and a continued loss of self-identity.^{5,6} Prosthesis embodiment⁷ is a process that reflects the ongoing adjustment to limb loss and adaption to wearing a prosthesis. This embodiment process

includes negotiating perceived changes not only in personality and identity but also across a wide range of quality of life domains including daily and occupational functioning, sex life, and relationships.^{7,8}

The design, function, and aesthetic appearance of prosthetic lower limbs have improved greatly over the past decade, with growing recognition that comfortable and easy-to-use lower-limb prostheses lead to greater satisfaction, activity, and overall quality of life.^{2,9-12} A systematic review¹² of measures of lower-limb prosthesis satisfaction revealed that patient satisfaction with lower-limb prostheses is a dynamic process influenced by a large range of factors including appearance, functional, and physical properties of the prosthesis, fit, and aspects of the residual limb. Critically, findings were inconsistent across studies, partly because of the range of measures and constructs used and also influenced by factors such as gender, cause and level of amputation, and liner use. The challenges in fully understanding the psychological impact of different types of prostheses at least partly reflect the

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Figure 1. Experimental manipulation for study 1.

methodological reliance on cross-sectional studies, the lack of use of appropriate and consistent validated measures, and variation between different groups of amputees.^{1,2,12} Moreover, less is known about how the wider population perceives individuals with limb loss, whether they hold stigmatic attitudes, or whether these perceptions differ according to the visual appearance of the prosthesis.

Emerging evidence¹³ suggests that different types of prostheses can elicit different emotions in nonamputees. Given that the main psychosocial challenges faced by amputees distinctly relate to their social identity, the impact of prostheses on attitudes of non-amputees and the extent to which they can impede or enhance social interaction appear to be important yet unanswered questions. Recent qualitative work with lower-limb amputees¹⁴ suggests that the opportunity to choose their own personalized design for a fitted prosthetic leg cover that provides both a more natural leg shape compared with a traditional stem and also enables the expression of one's personality or interests has been associated with improvement in self-reported quality of life and social functioning. The potential impact of being able to choose and design a bespoke customized prosthetic leg cover may, therefore, play an important role in the process of prosthesis embodiment and may also facilitate more positive social interaction.

This article specifically explores these issues in the context of lower-limb loss and considers the potential psychological impact of wearing a customized aesthetic prosthesis cover on attitudes and

social interaction cues of the general public. In line with a recent systematic review that has called for more novel assessment methods to evaluate the wider impact of prosthesis use,⁹ we propose that experimental methodologies from the fields of experimental social psychology and user design can enable us to explore these issues through the manipulation of images and videos and capturing attitudinal and behavioral data from participants.

The aim of the current research, therefore, was to gain a better understanding of the psychosocial impact of a customized aesthetic prosthetic limb. The specific objectives of the 2 studies reported here were to (1) explore whether viewing an image of an individual with and without an aesthetic prosthetic limb cover would lead to differences in participant attitudes and perceptions of the individual's personality traits compared with a nonamputee image and (2) to explore whether watching a video of an individual with and without an aesthetic prosthetic limb cover would lead to differences in the focus of attention across different contexts.

Materials and methods

All study procedures were approved by the University Research Committee and abided to the British Psychological Society Code of Human Research Ethics.¹⁵

Study 1 design

Study 1 was an online experimental between-subject study exploring the impact of viewing an individual wearing

Table 1. Judgment of BFI attributes by target (total scale range 2–10).

BFI facet	Expressive cover (1)	Stem (2)	Leg (3)
Extroversion	7.32 (1.51)	7.08 (1.43)	6.45 (1.28)
Agreeableness	7.34 (1.29)	6.79 (1.37)	6.23 (0.91)
Conscientiousness	7.69 (1.47)	7.89 (1.59)	6.47 (1.02)
Neuroticism	5.40 (1.48)	5.43 (1.15)	5.60 (1.09)
Openness	6.31 (1.22)	6.30 (0.84)	5.95 (1.03)

Abbreviation: BFI, Big Five Inventory.
Mean scores with standard deviation in parentheses. Scale range = 2–10.

a customized prosthetic leg cover on participant attitudes. To do this, 1 of 3 images of an individual was shown to participants. The same individual was presented in each condition and was an individual with a below-the-knee lower left leg amputation who consented to provide images for the study. Condition A was an image of the individual wearing a customized aesthetic prosthetic limb cover. Condition B was an image of the individual with a stem leg but no limb cover. Condition C was an image of the individual with a digital leg, so that he appeared to be a nonamputee (Figure 1).

Participants

Participants were 53 students from University of Wales Trinity Saint David recruited through a research management system for course credit, and 135 members of the adult UK general population, recruited through social media with no incentive offered for participation (N = 188).

Measures

Basic demographic data were collected (mean age = 37 years, standard deviation = 13.3; male 19%, female 80%, nonbinary 1% of the 170 who reported their gender) and whether they considered themselves to have a disability (less than 10% of the total sample [The majority of those classing themselves as having a disability reported these as psychological, and no participant reported amputation as a disability]).

Participants' perceptions of the personality of the individual in the photograph were measured using the 10-item Big Five Inventory (BFI-10),¹⁶ which is a previously validated brief questionnaire capturing perceived trait dimensions of extraversion, agreeableness, conscientiousness, neuroticism, and openness to experience. Participants had to indicate the level of their agreement across 10 items on a rating scale of 1 (strongly disagree) to 5 (strongly agree), with 2 items linked to each trait. Total scores for each trait ranged from 2 to 10 with higher scores equating to higher levels of the perceived BFI facet.

Participant attitudes toward prosthetic limb users were captured using an adapted version of the WHOQOL Attitudes Toward Disability Scale (ADS).¹⁷ The original 16-item ADS was developed to capture attitudes toward disability and people with disability across 4 domains: inclusion (relationships, inclusion, burden to society, and burden to family); discrimination (ridicule, exploitation, irritation, and ignorance); gains (emotional strength, maturity, achievement, and determination); and prospects (sexuality, underestimation, optimism, and future prospects). For the purposes of this study, the items on the original ADS were adapted

to capture attitudes toward prosthetic limb users specifically by replacing terms such as “people with a disability” with “people with a prosthetic limb.” Participants were asked to indicate their level of agreement with each statement on a five-point scale (1 = strongly disagree to 5 = strongly agree) with all domain subscale ranges from 4 to 20 and an overall ADS scale range of 16–80. For 3 of the 4 domains, higher scores reflect less positive attitudes, i.e., less inclusion, worse prospects, and more discrimination, whereas the gains domain subscale captures positive aspects of living with a prosthesis, so higher scores reflect more positive attitudes; therefore, this scale was reversed for the reported analyses, so higher scores equate to less positive attitudes on all domains. Cronbach's alpha is a measure of internal consistency, that is, how closely related a set of items are as a group, with scores between 0 and 1 and scores of 0.7 or above reflecting good psychometric reliability. Internal reliability using Cronbach's alpha statistics of the original ADS is consistently above 0.7 across different cultural groups,¹⁷ and in the current study, the overall ADS reported an alpha coefficient of 0.72 with the adapted subscales reporting alpha coefficients of 0.64 to 0.79.

Procedure

Participants completed the study online and were randomly allocated to view 1 of the 3 images. Participants were asked to “Please think about prosthetic limbs and people with prosthetic limbs in general and select how much you agree with each statement below.” They were then asked to complete the BFI-10 followed by the adapted version of the ADS and demographic questions.

Results

Data from the 188 participants were cleaned and screened, and boxplot analysis showed that no data fell outside of acceptable boundaries. Of the 188 participants, 65 viewed the individual wearing the aesthetic leg cover, 61 viewed the individual wearing the stem leg, and 62 viewed the individual as a nonamputee. Table 1 reports all mean values and standard deviations for the judgments of personality across these 3 conditions.

A series of between-group analyses of variance were performed to explore differences across conditions by personality trait.

A significant difference was found for extroversion judgments ($F(2,185) = 6.41, p = 0.002$) with post hoc analyses showing that participants judged both the image with the stem leg ($t(121) = 2.58, p = 0.01$) and aesthetic cover ($t(125) = 3.50, p = 0.001$) as being significantly more extroverted than the nonamputee image.

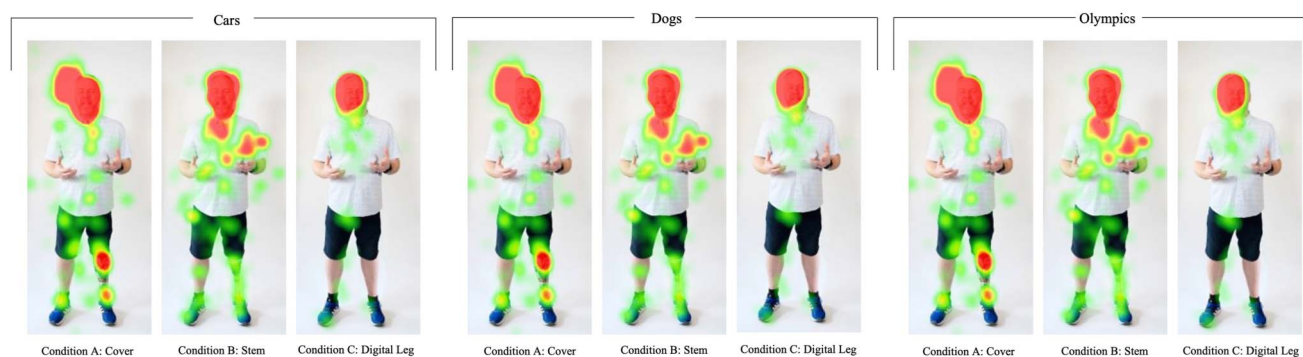


Figure 2. Experimental manipulation and attentional focus.

There was no significant difference between extroversion ratings of the images with the aesthetic cover and stem leg ($t(124) = 0.92$, ns).

A significant difference was found in judgments of conscientiousness ($F(2,185) = 19.20$, $p = 0.001$). Both the leg cover ($t(125) = 5.44$, $p = 0.001$) and stem images ($t(121) = 5.89$, $p = 0.001$) were judged as being significantly more conscientious than the nonamputee image, but no significant difference emerged between the stem and aesthetic cover images ($t(124) = 0.71$, ns).

There was also a significant difference in judgments of agreeableness ($F(2,185) = 13.48$, $p = 0.001$). The aesthetic cover image was rated significantly more agreeable than both the nonamputee image ($t(125) = 5.59$, $p = 0.001$) and the stem image ($t(124) = 2.33$, $p = 0.02$), whereas the stem image was also rated significantly more agreeable than the nonamputee image ($t(121) = 2.68$, $p = 0.01$). No significant differences were found between any judgments of the 3 images for neuroticism ($F(2,185) = 0.45$, ns) or openness ($F(2,185) = 2.32$, ns).

Participant attitudes toward people with a prosthesis on the ADS domains are displayed in Table 2. No significant differences were found for any of the ADS subtypes or total scores across the 3 conditions meaning that participant attitudes did not vary according to whether they viewed the aesthetic leg cover, stem leg, or nonamputee image (inclusion ($F(2,177) = 0.79$, $p = 0.46$); discrimination ($F(2,177) = 0.48$, $p = 0.62$); gains ($F(2,177) = 0.02$, $p = 0.99$); and prospects ($F(2,177) = 0.03$, $p = 0.97$).

Study 2 design

Study 2 was a behavioral observational pilot study exploring whether viewing the individual wearing the customized aesthetic leg cover over the stem prosthesis resulted in changes to participant

facial responses whether more participant's gaze is directed to the cover itself than the individual's face compared with the stem leg or nonamputee image. Nine video manipulations were created using the same individual as in study 1 with the same 3 conditions. The videos involved the individual talking about 1 of 3 topics (cars, dogs, and the Olympics) across each of these conditions for 1.5 minutes, making 9 conditions in total.

Participants

Participants were 31 students at XXXX.

Measures and analysis

Eye-tracking measures were used to capture the amount of time each participant looked at the target area of interest (the left lower-limb area) in 1 of the 9 conditions. Tobii Pro Lab¹⁸ was used to perform the analyses, as it is designed to calculate fixation by taking the raw gaze points and using their velocity, time, and distance of eye movements to measure where attention has been spent (Figure 2). In addition, Noldus FaceReader¹⁹ was used to analyze facial expressions in participants. The valence dimension of the FaceReader measures the positivity or negativity of an emotional response on a scale of -1 to $+1$ with negative scores indicating a more negative response, whereas the arousal dimension measures the level of emotional activation on a scale of 0 to 1 with higher scores indicating more powerful emotion activation.

Procedure

Data collection took place in 2 main settings, a dedicated laboratory setting and also in a quiet space on a university campus.

Table 2. ADS mean scores by ADS subtypes and condition (viewed image).

ADS subtype	Expressive cover M (SD) N = 63	Stem leg M (SD) N = 59	Digital leg M (SD) N = 58	Mean score by ADS subtype M (SD) N = 180
Inclusion	7.54 (2.08)	7.83 (2.29)	8.07 (2.59)	7.81 (2.32)
Discrimination	11.14 (3.21)	10.61 (3.18)	10.74 (3.04)	10.84 (3.14)
Gains	9.65 (2.74)	9.63 (2.51)	9.71 (2.29)	9.66 (2.51)
Prospects	5.82 (2.12)	5.78 (2.05)	5.72 (2.43)	5.78 (2.19)
Total ADS score	34.16 (5.70)	33.85 (6.79)	34.24 (6.89)	34.06 (6.43)

Abbreviations: ADS, Attitudes Toward Disability Scale; SD, standard deviation.
Subtype scale range = 4–20; total ADS score range = 16–80.

After consent, each participant was randomly shown 1 of the 9 videos while eye-gaze behavior and facial expressions were recorded. It was felt that because of the limited number of scenarios available (1 actor, 3 limb types, and 3 descriptive scenarios), this between-participant approach would introduce less response bias than presenting multiple videos to the same participant.

Findings

In all conditions, as would be expected when viewing an individual speaking, most participant fixations were on the individual's face (Figure 2). However, in all 3 conditions (car, dog, and the Olympics) involving the aesthetic cover participants directed attention toward the cover, allocating some of their viewing time to focus on it (Table 3). Particularly during the Olympics and cars conditions, the aesthetic cover garnered the highest collective attention from participants barring the face, becoming a prominent point of visual interest. This pattern of gaze fixation suggests that although overall more attention is paid to the aesthetic cover, context is an important factor; attentional gaze is directed more toward the aesthetic cover when talking about action-related topics (cars and the Olympics).

Although no clear differences emerged regarding valence and arousal of emotion in the examination of facial expressions (Table 3), arousal levels for the aesthetic cover/car condition was marginally higher than for the stem and nonamputee car conditions, again suggesting that context may be an important factor to consider in this type of research.

Discussion

The purpose of this research was to use novel methodologies to explore the impact that a customized aesthetic prosthetic leg cover can have on attitudes toward an individual with an amputation and the immediate behavioral impact on the direction of gaze. Study 1 found that individuals made more positive judgments on the BFI-10 about the perceived personality of a prosthesis wearer regardless of whether wearing a stem prosthetic or aesthetic leg cover, with the individual rated as more conscientious and more extraverted than when viewed as a nonamputee. In addition, participants rated the aesthetic leg cover wearer as more agreeable than either the stem prosthesis wearer or nonamputee, despite being the same individual in all conditions.

The results of the ADS attitude scale showed the aesthetic leg cover had no significant impact on the attitudes of the general population compared with either the traditional stem leg or a nonamputee, with most attitude scores being positively skewed. However, participants perceived prosthesis wearers as

experiencing moderate forms of discrimination, ratings of inclusion, gains, and particularly prospects indicated positive attitudes. Although these data suggest that perceived stigma toward prosthesis wearers may not exist as much as perceived, a recent article has also cautioned around the possible impact of perceiving people with wider disabilities as being inspirational or even “super-human” as it is also important to recognize the significant challenges faced by those living with amputation.²⁰ In study 2 while viewing the different video and leg scenarios, participants focusing mainly on the facial area regardless of the leg or film condition. Given the recognized importance of facial communication in everyday settings,²¹ our modest findings suggest that wearing a customized aesthetic limb cover does not impede critical social interaction cues. Nevertheless, the aesthetic leg cover did result in increased attentional focus on the limb compared with the other conditions, particularly when viewing more active contexts.

Taken together, our study findings could help inform clinical conversations and patient-facing interventions and literature in the early days of adaptation to limb loss, supporting shared decision-making around choice of prosthetic design (where clinically appropriate) and providing suggestions and positive strategies to support self-identity, self-confidence, and ultimately encourage successful prosthesis embodiment. Overall, the results of this study go beyond Vlachaki et al's¹¹ qualitative findings that prostheses that are specifically designed to highlight the user's identity can have a positive impact on the self-confidence of the individual with the amputation by suggesting that, perhaps contrary to the self-stigmatic view often reported, this positive impact goes beyond the user itself and also impacts on how others view the individual. There are currently few psychosocial interventions or educational campaigns specifically focused on attitude change, reducing self or public stigma, and improving the quality of social interactions in individuals with an amputation and prosthesis wearers.⁶ Our study supports Vlachaki et al's suggestion that aesthetic prostheses or covers could be a useful tool for raising awareness, reducing stigma, and increasing social acceptance, particularly in individualistic societies. The extension of the experimental methods such as those reported in the current article to larger samples can help researchers and clinicians further understand the individual and wider societal and emotional impact of such initiative across different contexts.

There are of course a number of methodological limitations to the current study. Only 1 target person was used for the manipulations and the between-group designs meaning that it was not possible to consider within-subject variation. A significantly larger sample size would be needed to achieve this in future studies. We also only used a male target figure, and recent studies have called for greater consideration of sex and gender constructs

Table 3. Average area of interest fixations, valence, and arousal per condition.

	Area of interest			Valence			Arousal		
	Olympics	Dogs	Cars	Olympics	Dogs	Cars	Olympics	Dogs	Cars
Stem	3.74	1.55	3.91	−0.11	−0.03	−0.07	0.28	0.29	0.27
Cover	6.15	1.86	6.09	−0.11	−0.08	−0.10	0.32	0.27	0.40
Leg	2.64	0.21	0.00	−0.12	−0.04	−0.03	0.28	0.30	0.31

Valence scores measured on scale of −1 to +1; arousal scores measured on a scale of 0 to +1.

that may influence psychosocial outcomes.²² Finally, this research only captured explicit attitudes, and it is possible that also including more implicit measures through the use of an Implicit Association Test²³ may have provided additional insight into more prejudicial attitudes.

Conclusions and recommendations

The experimental methodologies used within this research study have enabled us to explore unique facets of the psychosocial processes underpinning how the general population perceives people with a prosthesis and the impact that wearing a customized aesthetic prosthetic leg cover can have on that perception. The findings have clinical and research significance by adding to our understanding of the ways in which the continued development of prosthetic limbs and associated visual aesthetics can help individuals living with limb loss to better prepare to navigate the social discomfort and body-image concerns inevitably experienced during the process of adaption to both the initial limb and living with a prosthesis.

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Supplemental material

No supplemental digital content is available in this article.

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