A Survey on What Australian's with Upper Limb Difference Want in a Prosthesis: Justification for using Soft Robotics and Additive Manufacturing for Customised Prosthetic Hands

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Upper limb prostheses are part of a rapidly changing market place. Despite development in device design, surveys report low levels of uptake and dissatisfaction with current prosthetic design. In this study, we present the results of a survey conducted with people with upper limb difference in Australia on their use of current prostheses and preferences in a prosthetic in order to inform future prosthetic hand design. We isolate common key issues/concerns raised in the survey relevant to the design of a prosthetic hand – weight, manipulation and dexterity, aesthetics, sensory feedback, and financial cost – and show how each could be addressed by additive manufacturing and soft robotics techniques. The adaptability of these techniques to these concerns shows that further research and development into additive manufacturing and soft robotics is a feasible method to improve patient satisfaction and acceptance in prosthetic hands.

1. Introduction

There is a range of estimates for prosthetic rejection rates, with estimates of up to as high as 40% [1]. Further, 82% of upper limb prosthetic device owners use their devices in grasping-related tasks half of the time or less [2]. There have been several surveys conducted on upper limb prostheses regarding their rejection [1, 3, 4, 5, 6], views on control mechanisms [7] and sensory feedback [8, 9], as well the embodiment of prosthetic devices for amputees [10]. However, thorough surveys conducted on prosthetic user populations [2, 5, 11, 12] are quite old relative to developments in materials and engineering techniques. In the last six years, surveys have focused on specific questions (e.g. on novel control techniques [7]) and the most recent survey [13], whilst providing

free response feedback from seven upper limb amputees, focussed on their challenges and difficulties faced throughout the day. Without any structured questions, it relied on common themes being raised by the respondents and was therefore unable to provide any quantitative information, such as ranked lists of difficulties and design priorities etc. When examining the views of those with limb difference, similarly other previous surveys have focussed on the reasons for dissatisfaction with current prosthetics and rejection, with minimal attention paid to the preferences of users of prosthetic devices. Instead of inferring what users want from questions about dissatisfaction, this present survey incorporated questions about preferences from those with upper limb difference ,including open ended responses, as input to shape future prosthetic designs. In addition the survey solicited responses to determine what areas soft robotics and additive manufacturing can contribute towards, \ achieving the highest benefit for the users.

Upper limb prosthetic devices are part of a rapidly changing market with many recent developments [14, 15], particularly in multiple digit prostheses and advances in their design, manufacturing, control and performance. Many of these developments are not yet close to market suitability to meet needs and concerns of people with upper limb difference associated with current upper limb prosthetic devices [14, 15]. Additive manufacturing is an enabling technology to create cost effective [16], lightweight [17], and customisable [18] prosthetics.

Soft robotics is an emerging research area [19, 20, 21, 22, 23] which provides an advantage of being adaptable and conformable to unknown environments through the use of lightweight and soft components with programmable compliance. Through strategic design of the intrinsic properties of the chosen soft materials, soft robotics can be used to mimic parts of some biological organisms by incorporating a one-piece compliant mechanism with flexible bending points to undergo large deformations and adapt to the

shape of the object being gripped or interacted with, rather than using multiple rigid components and joints as used in traditional robotics [20]. Although soft robotic devices have been manufactured by moulding methods [24, 25], with strategic design and material selection, soft robotic devices can be manufactured using additive manufacturing processes [26, 27]. This reduces manufacturing costs and allows the creation of complex geometries by shortening the path from ideation to the proof of concept [20]. Both soft robotics and additive manufacturing offer great potential for the field of prosthetic devices and could meet some of the needs and desires of those with upper limb difference. Given rates of uptake and expressed dissatisfaction with current prosthetics, it is reasonable to assume that some of the issues are related to prosthetic design could be addressed by emerging techniques such as soft robotics and additive manufacturing.

There are three aims that this study seeks to address:

1) Provide a more recent survey focused on people with upper limb difference within Australia where researchers are located and where the last survey conducted was in 2002 [2].

2) Receive direct input from potential users such that this input can help shape the future direction of design and fabrication of upper limb prostheses.

3) Assess which of these current problems, desires and needs identified from the participants survey responses can be addressed using soft robotics and additive manufacturing technologies in the development of upper limb prostheses.

2. Materials and Methods

An online survey was created to obtain feedback from people with upper limb difference about their experiences of and desires for prosthetics using the Qualtrics

Insight platform. An interdisciplinary research team at the ARC Centre of Excellence in Electromaterials Science (ACES) with the expertise in bioethics, engineering and biomedical device design, particularly advanced prosthetic design undertook this research. Questions were related to functionality, appearance and sensory feedback. Questions on the impact of a prosthesis on work and daily life, relationships and identity were also asked but those results and analysis will be reported on elsewhere and are not discussed within this manuscript. In addition, information about age, sex, reason for limb difference and time since limb loss was requested. Open ended free response text questions were used when feasible, and questions were phrased as neutrally as possible to reduce any unintended guidance to the response. Participants, who were people with upper limb difference, were asked to respond to quantitative questions such as ranking the features they would like to see in the future prosthetic hands, and to provide qualitative feedback on problems experienced and desired attributes of prosthetics. The results are displayed in a combination of graphs and tables, followed by a discussion of the common key points raised in the responses, and their implications for various aspects of prosthesis design. One aim of this manuscript is to assess which of these desired improvements and changes to prosthetic devices can be addressed by using the soft robotic and/or additive manufacturing approach. Refinements and alterations were made after the survey was reviewed by people with upper limb difference and advocacy groups, including Limbs 4 Life Australia and Amputees New South Wales, as well as individual stakeholders. The survey flyer, which contained a brief description and a link to the website, was disseminated through a variety of methods; including private networks, social media, post, email and e-newsletters; and distributed via a range of networks including Australian amputee and limb difference support and advocacy groups, rehabilitation clinics and hospitals, authors' universities, and professional

associations of prosthetists, orthotists, occupational therapy and rehabilitation workers.
The survey was open to participants for 6 months during 2017. IP addresses were
collected by our software to prevent repeat submissions.

Table 1 - Survey Participant Breakdown (AE: Above Elbow, BE: Below Elbow)

Participants (n (%))		
Sex	Female	17 (62.9)
	Male	9 (33.3)
	Not disclosed	1 (3.7)
Age in years (average)	40.8	
Limb difference	Unilateral right AE	6 (22.2)
	Unilateral left AE	2 (7.4)
	Unilateral right BE	5 (18.5)
	Unilateral left BE	5 (18.5)
	Bilateral (left AE, right AE)	1 (3.7)
	Bilateral (left BE, right BE)	5 (18.5)
	Partial hands and fingers	1 (3.7)
	Not disclosed	2 (7.4)
Reasons for limb difference	Congenital	7 (26.9
	Injury or trauma	5 (19.2)
	Cancer	5 (19.2)
	Sepsis/infection	8 (30.8)
	Complications from surgery	1 (3.8)
Time since limb loss[1]	Less than 3 months	0
	3-6 months	1 (6.7)
	6 months – 1 year	1 (6.7)
	1 – 2 years	3 (20)
	3 – 5 years	4 (26.7)
	5 – 10 years	2 (13.3)
	10 – 20 years	4 (26.7)
	More than 20 years	0

Table 2 - Breakdown of types of prosthetic devices used by participants

Types of prosthetics used by survey participants (n (%))	
None	12 (44.4)
Cosmetic	2 (7.4)
Hook	5 (18.5)
Body powered	5 (18.5)
Myoelectric	7 (18.5)
Bebonic	1 (3.7)
COAPT system	1 (3.7)
Straps to hold implements	1 (3.7)
Not disclosed	1 (3.7)

N.B. *Total > 100% due to multiple prosthetics or prosthetics that fit into more than one category*

Informed consent was obtained from each individual when they began the survey, and ethical approval was obtained from Monash University Human Research Ethics Committee. Qualitative analysis of any free response answers was undertaken independently by two of the researchers (MW and BSF), followed by a discussion for consensus on interpretation. Any groupings of key points are tabulated in decreasing order of the number of participants that it was raised by.

2.1. Limitations

35 responses were received, but those who only provided demographic data were removed. In total, there were 27 respondents that completed the survey and the participant breakdown is shown in table 1. Participants' responses were still retained if they skipped the free-text section or occasional questions. This small convenience sample is a relatively small proportion of the population and is unlikely a representative sample (due to the dissemination method, and as indicated by the low average age and high proportion of female participants). However, the authors propose that these results are still able to provide useful feedback on the current experiences and desires of people with upper limb difference. In order to maintain our focus on the Australian context, the authors chose not

to open it up to those residing in another country to increase the sample size.

Even though we consulted with people with limb difference in designing the survey, this consultation could have been more extensive. Ideally, we could have included people with limb difference as co-designers and analysers. Further, while we aimed to phrase questions neutrally and in ways that did not constrict or frame potential responses, in view of responses received this may not always have succeeded. For instance, in the question on preferences about look, we included in parentheses "e.g., lifelike, uncovered or 'skeletal', customised design, other" with the intention of making the question clear. However, this may have influenced people to choose one of these responses.

As the survey was guided by the specific aims noted above, and to avoid unintentionally guiding responses, it is not intended to provide comprehensive information on preferences about all aspects of prosthetic design or manufacturing. For example, no specific questions were asked regarding the socket and/or its interaction with the residual limb, although it would presumably help contribute to a participant's perception of comfort. In addition, no questions were asked regarding the incorporation of a wrist into a design, but it did come up through other free text responses regarding functionality and dexterity.

3. Results

Figures 1-2 and tables 3-5 provide a collation of the results of the questions about participants' current experiences of their prosthetic device(s). Figure 1 shows average daily usage of their device.
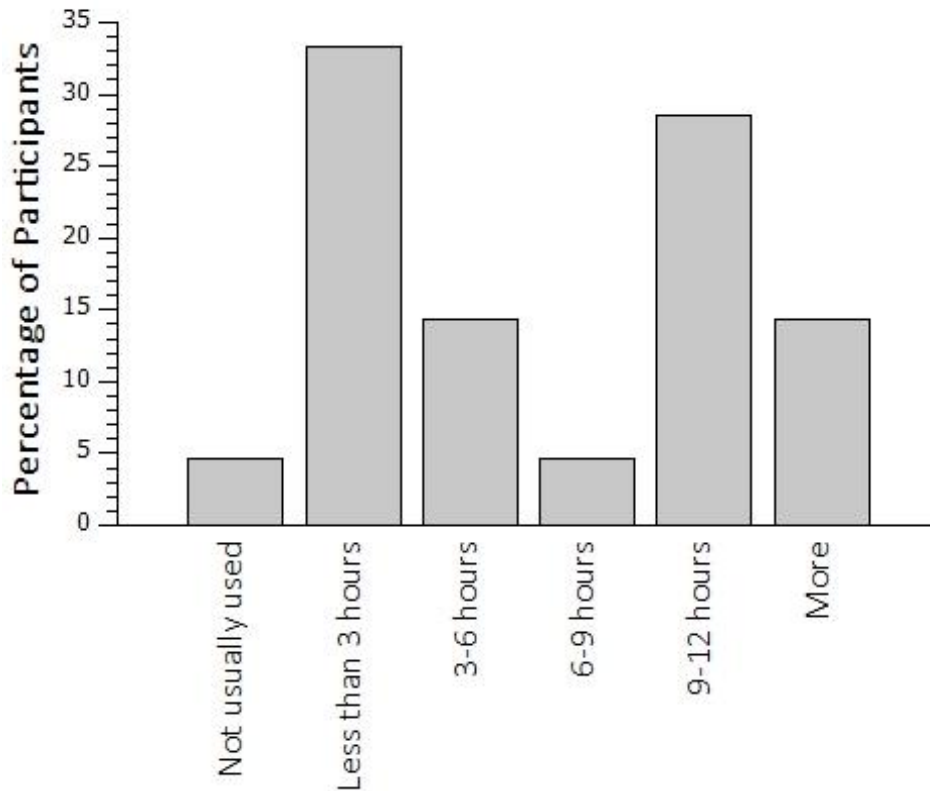
Figure 1 - Average Hours of Prosthetic Use

In a follow up question, 84.7% of respondents indicated that there are specific times or activities that they prefer not to wear a prosthetic device. Their reason was provided as an open text response and the authors identified three common key points, as shown in table 3. These were placed in descending order based on the number of times they were mentioned by the participants, and participants responses sometimes contributed to more than one of them. Participants raised some issues associated with (i) size and weight: the prosthetic was "heavy and clunky" or "too long and too heavy and awkward", and (ii) functionality and dexterity: the prosthetic lacked "wrist flexion" or caused "clumsiness".

Table 3 - Reasons for not Wearing Prosthetic, in descending order.

	Key Point	Number of Participants
1)	Size and Weight	4
2)	Functionality and Dexterity	4
3)	No need to use the prosthetic	2

In addition, 66.7% of the participants indicated that they had changed the kind of prosthesis they use. Their reasons centred around, for example, the prosthetic was "heavy and clunky" or "too long and too heavy and awkward", the prosthetic lacked "wrist flexion" or caused "clumsiness". These reasons were collated by the authors and ranked in descending order based on how common these key points appeared within the responses, some answers contained multiple key points.

Table 4 - Reasons for Changing Prosthetic, in descending order.

	Key Point	Number of Participants
1)	Functionality and dexterity	3
2)	Size and weight	1
3)	Reliability	1
4)	Financial capacity	1
5)	Altered self-understanding	1
6)	Look	1

Participants were asked to identify issues with their current prosthesis in a free text response. These responses were grouped together in common key points and are presented in Table 5. Each participant's response can contribute to more than one key point.

Table 5 - Problems with Current Prosthesis, in descending order.

	Key Point	Number of Participants
1)	Limited functionality	4
2)	Size and weight	3
3)	Reliability	3
4)	Ease of use and comfort	2
5)	Design trade-offs/problems	1

Similar to responses in previous surveys [4, 13], limited functionality and the large size and weight of current prosthetics are still listed as the largest problem with current prosthesis.

Figure 2 breaks down the source of funding used for purchasing each participant's prosthetic device.
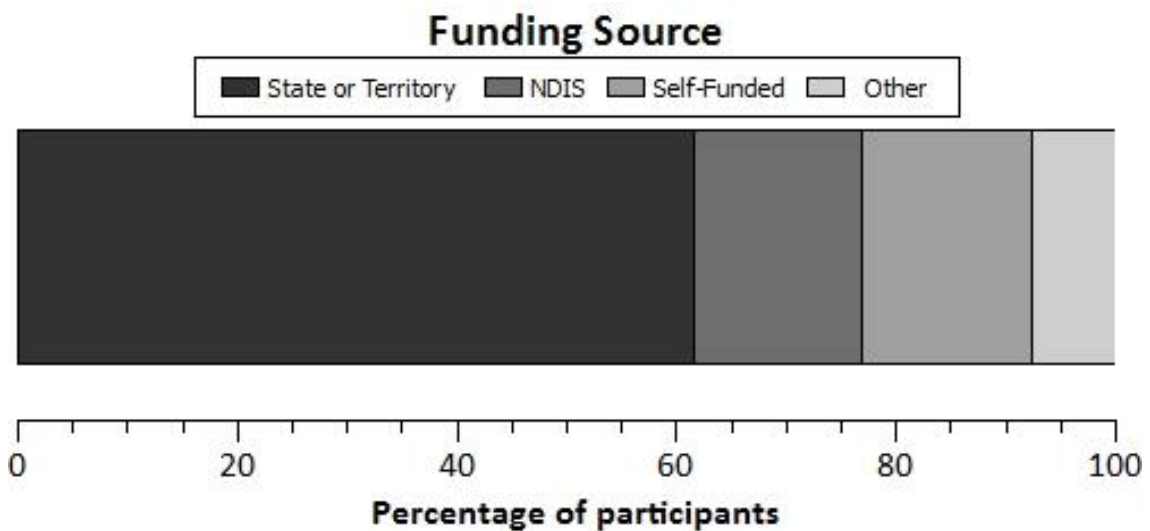

Figure 2 - Payment method for participants' most recent prosthetic. N.B. National Disability Insurance Scheme (NDIS) is a scheme in which the Australian government provides support for those with a permanent and significant disability to its citizens and permanent residents.

Tables 6 and 7 outline the type of activities and grasping tasks that participants reported were most important to be able to use their prosthetic device for.

Participants were asked what activities were most important to them to be able to do them with a prosthetic device. Their responses were given in a free text response and were collated and ranked in descending order based on how commonly these key points appeared within the free text responses, some responses contained multiple key points within them. These key points are presented in Table 6.

Table 6 - Most Important Activities for Prosthesis, in descending order.

	Key Point	Number of Participants
1)	Activities of daily living	13
2)	Sport and leisure activities	6
3)	Writing/Typing	6
4)	Driving	5

When participants were asked if there were tasks they currently did not use their prosthetic device for, many of the respondents indicated tasks such as everything presented in the previous question (shown in Table 6), or "so much more", indicating a large non-satisfaction with current performance of prosthetics. In addition to using terms such as those shown in table 6, responses included statements such as enabling tasks such as eating, holding mobile phone, handling a wallet, cooking, being able to hold their children.

Table 7 presents a collated list of most desirable grasping types by the participants. They were asked to provide the most important grasping and manipulation tasks for them in a free response form. The authors classified responses as indicating a desire for reliable

grasp where a participant simply indicated wanting to be able to have and keep hold of an object (e.g., "holding […] cans, jars" or "steadying objects"); a strong grip where strength was specifically mentioned or indicated as desired (e.g., "strong secure grip" and for "picking up heavy items"); and a precise grip where the response indicated a desire to control grip strength (e.g., "touch grip strength so doesn't crush things").

Table 7 - Most important grasping and manipulation tasks, in descending order

	Key Point	Number of Participants
1)	Fine and Delicate tasks	5
2)	Reliable Grasp/Hold	5
3)	Strong Grip	3
4)	Precisely Controlled Grip	3

Participants were asked to rank the importance of various design features using a sliding bar scale of 0-5, with 0 being the least important and 5 being the most important. If a participant did not provide a response for one of the features, it was not considered in the calculations. Figure 3 shows the average rating for each of these factors.

In addition, participants were asked what factors determine their choice in prosthesis selection. The top three choices are shown in figure 4.

Three participants also selected an "other" option, indicating preference of comfort, strength and weight being high priorities.
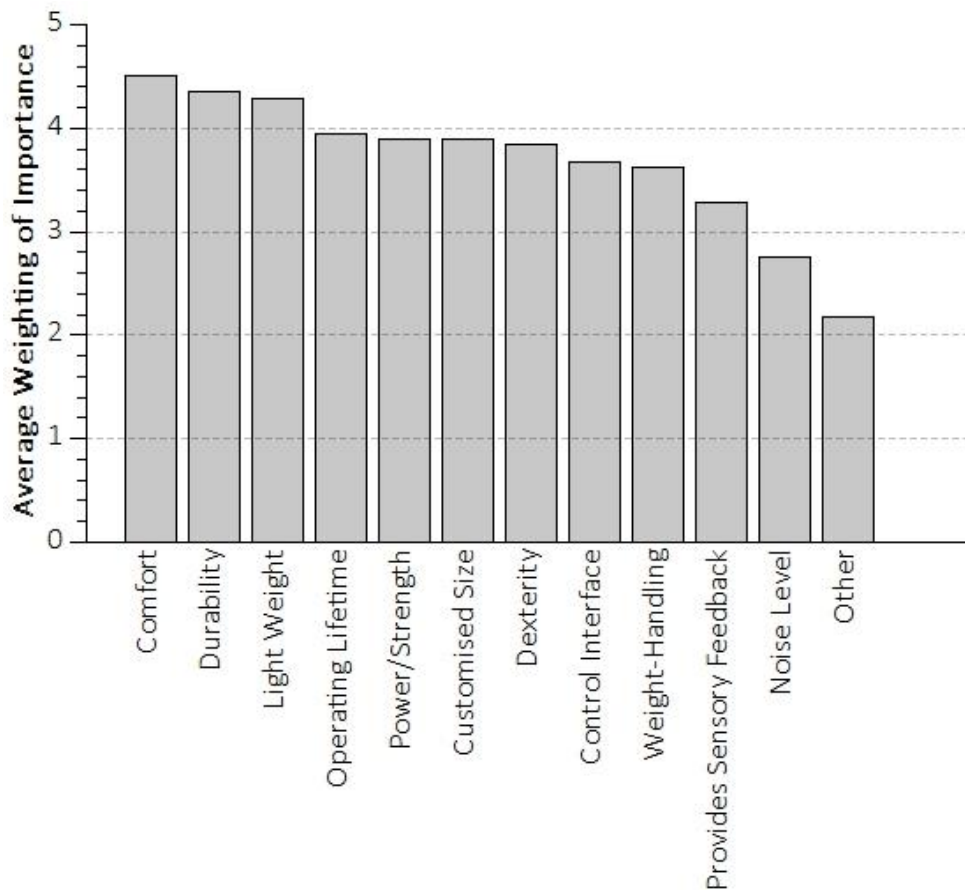
Figure 3 – Average Weightings of importance

Participants were asked to identify their preference for how they would like their prosthesis to appear and provide their reason in a free response form. However, they were given the examples of "lifelike, uncovered or 'skeletal', customised design, other". They were able to provide more than one option and these were grouped together, as presented in Table 8. The only "other" option was for a robotics/cyborg look indicated by four participants.
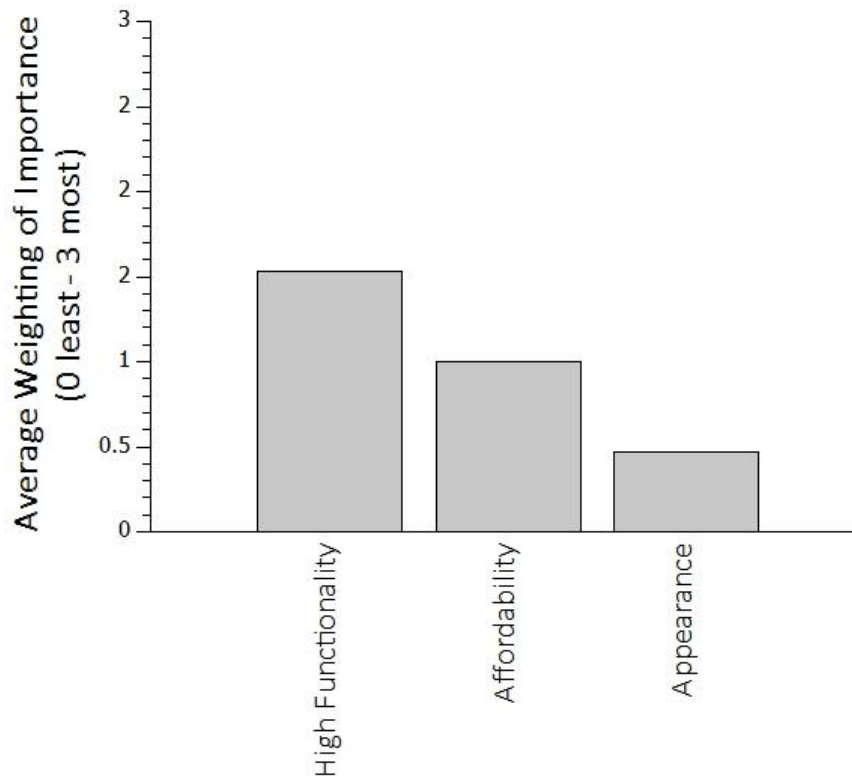
Figure 4 - Average of participant's ranking of importance of considerations in choosing a prosthetic (1 - least important, to 3 - most important

Table 8 - Preference on prosthetic appearance. (N.B. some indicated that they like more than one kind of look, N=18)

Preference	Frequency
Life Like	8
Customisable	3
Robotic/cyborg	4
Skeletal/uncovered	3
Appearance unimportant	2

As shown in Table 8, within this sample there was a varied level of response to aesthetic appearance. In addition, the language used was often quite strong when they described their preference of appearance (lifelike vs robotic/skeletal). E.g. one survey participant wanted their prostheses to look "lifelike so I blend in with the crowd" whereas another

participant responded that their preference was "Definitely not lifelike" but rather a "customised design".

Participants were given a free response question to detail what sensory feedback sensations would be desirable for them. The results are grouped into common key points in Table 9. Some participants responded with more than one type of sensation, whereas responses of multiple participants were either left blank or indicated they were "not sure". This may indicate that some participants have not considered how it would be helpful, particularly if they have fundamental problems with their prosthetic that caused them to give up using it all together, and it may be difficult for them to imagine both it is being useful and what it would be like [28].

Table 9 - Participants' interest in different types of sensory feedback

Sensory Feedback	Frequency
Grip Strength	7
Feeling of touch	5
Temperature	1
Texture	1
Not sure	2
Not interested in sensory feedback	1

One avenue for application of natural and efficient non-invasive sensory feedback is through the use of Phantom Limb Maps [29, 30, 31, 32, 33] from those who have undergone amputation. Phantom digits or a phantom hand map is a phenomenon where touching a specific area on the residual limb causes the feeling that one of the missing fingers is being touched. However, these phantom digits are not experienced by all amputees and their locations can vary. Their prevalence is also unknown amongst those with upper limb difference. Within the participants who had undergone amputation, i.e.

excluding those with congenital limb difference, 47% indicated that they had at least one of these phantom digits. This is lower than the previously reported value of 12 out of 18 participants (66%) reported by Ehrsson et al. [34]. It may be possible that the other participants are unaware of this phenomenon and/or have not discovered it yet or may have more spots not identified if they are smaller regions. It is worth noting that both of these studies have very small sample sizes so are not a reliable indication of the wider population. For the participants who indicated they had phantom digits, Figure 5 provides a breakdown of the number of corresponding digits for which this phenomenon occurred, as well as a breakdown of the number of times each digit had a corresponding phantom digit for nine participants.
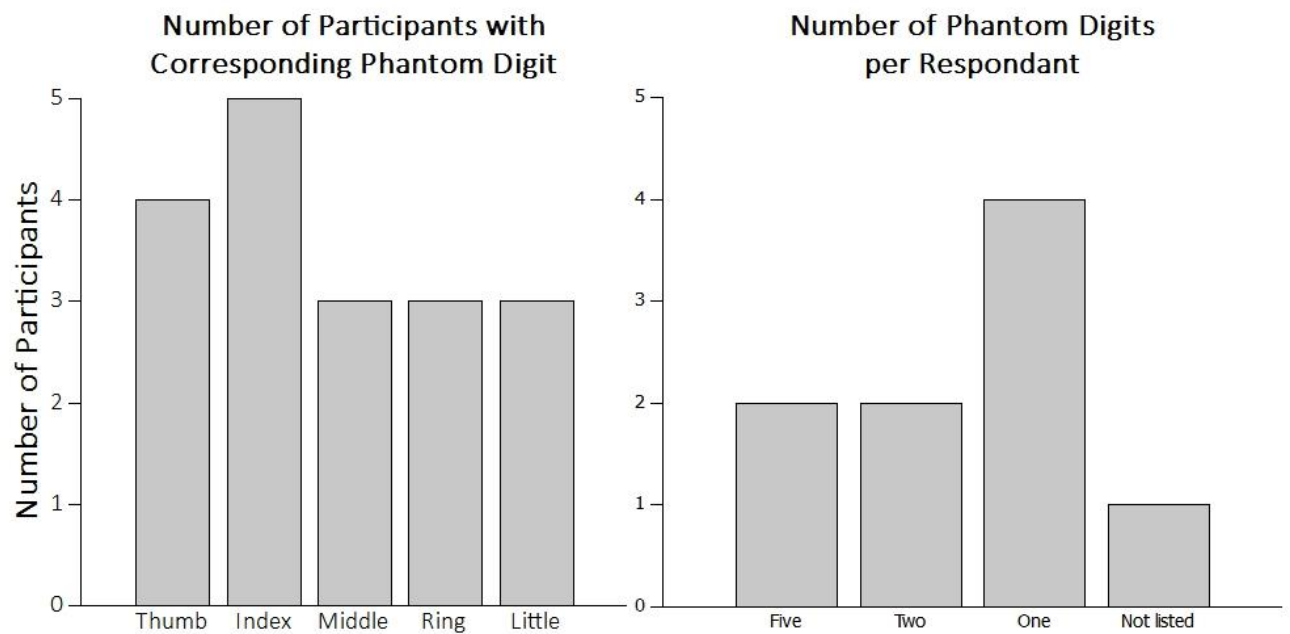

Figure 5 – Phantom digits breakdown from those who indicated them

The largest benefit to using phantom digits as a site for sensory feedback comes from being able to easily distinguish between multiple sites and correctly associate them without training or learning of substitution feedback methods. However, four out of nine

participants indicated they only had one phantom digit, which minimises any advantage it may have over substitute sensory feedback.

4. Discussion

The average time that participants use their prosthetic device each day is shown in Figure 1. Consistent with previous surveys [1, 2], our data shows that there is still an under usage of prosthetic devices, with 52.3% of individuals who owned a prosthetic using their device for less than 6 hours per day. This indicates that users, are still either not satisfied or do not take themselves to derive sufficient benefit from their current prosthetic device. Given our survey responses, it is reasonable to assume that considerations in design may be a factor in this dissatisfaction. Therefore, the key design points of weight, manipulation and dexterity, sensory feedback, aesthetics and costs will be analysed in this section. A recurrent idea throughout these sections is that both a soft robotic approach (using soft materials to establish conformable, light weight, low cost and low foot-print devices, here typified by prosthetic hands) to prosthetic devices and additive manufacturing (for ease of customisation and reduction in cost) can be expected to improve prosthetic devices in many of the ways potential users desire.

4.1. Weight

As shown in Figure 3, weight is very important in design features of prosthetics. By itself it ranks third, and it also contributes to the comfort of a prosthesis, ranked first. That the current weight of prosthetic hands is a major issue needing improvement in the establishment of new prosthetic devices was further borne out by participants' free text responses as shown in Tables 3-5. Participants' responses indicated that when considering

comfort, they experienced issues surrounding the socket connection, as well as the contribution that the weight makes to the overall comfort. The recent approach of soft robotics for prosthetic devices [19, 20, 35] provides a possible pathway to greatly decrease the weight, whilst still enabling fine motor control and manipulation. Due to the materials' compliance and adaptability, they rely on under actuation and can conform to the object's shape, thus allowing a reduction in the number of actuators or motors required, which impacts the overall weight of the hand.

A major contributor to the weight of the hand is the battery and although the battery size may be reduced as a result of fewer actuators, it will still be a major contributor. Recently there has been success into the development of 3-D printable batteries [36], which could assist to locate the battery into the position with the minimal impact on the weight of hand, allowing it to conform to the available space and spread the weight distribution.

4.2. Manipulation and Dexterity

In line with the wide variety of prosthetics available in the market [14, 15], prosthetic hands are increasing the number of controllable digits and their dexterity. However, as shown in Figure 4, increasing functionality is still one of the most important features of the prosthetic devices. There are several factors including accessibility due to costing, weight, sensory feedback and control algorithms which should be considered together with the functionality. Although prosthetic hands currently have the ability for fine motor control, they are limited in the controllability from the user, typically through myoelectric signals. It is currently difficult to achieve proportional fine motor control through myoelectric signals. In addition, visual feedback does not provide enough information for

appropriate control of hands [37]. Therefore, providing sensory feedback is an important part of increasing the user's ability to enable fine control, which current top-end prosthetic devices do not have. Typically, as the functionality of the hand goes up, so does the requirement for high performance actuators and other components, which affect both the weight and cost of prosthetic hands. This could be one explanation for why only 22.2% of participants in this survey owned a myoelectric prosthetic device. As discussed, employing recent progress in soft robotic approaches, using manufacturing technologies including additive manufacturing, may provide one pathway to maintain the fine dexterity required, whilst minimising cost and weight [38].

4.3. Aesthetics

As shown in Table 8, there is no overwhelming consensus on what kind of appearance is preferred and free-text explanations of preferences indicated that participants had strong personal reasons for their preferences. For example, some preferred a lifelike appearance as they did not want to stand out, whilst others wanted to stand out from the crowd and for people to notice their prosthetic device. Traditional manufacturing methods, however, make it difficult and expensive to provide various options. The increasing ability in developing prosthetic hands through additive manufacturing provides a pathway that will easily enable a high level of customisation for users, not only in their look but also in the appropriate sizing, whilst minimising cost and weight. Taking an additive manufacturing approach also enables possibilities for distributed/on-site manufacturing for prosthetic fitters and to provide easier access, particularly in developing countries.

4.4. Sensory Feedback

Although sensory feedback is listed lower on the priority list than other features, as shown in Figure 3, it still has an average weighting of 3.3 / 5. However, sensory feedback can play a significant role in achieving the desired grasps outlined in Table 7 (apart from strong grip). In addition, due to this feature not being readily available there is a lack of familiarity/knowledge of its potential capacity with some participants responding they were "not really sure" or "literally have no clue" with what sensations would be most important to them. Although there has been extensive research on sensory feedback techniques [39, 40, 41, 42, 43], they have not made it to marketplace yet. There is still therefore a great need for a simple, yet practical and effective sensory feedback method.

4.5. Costs

Improvements in prosthetic devices can also increase cost. Affordability is a concern for current prosthetic users, as shown in Figures 2 and 4, and Table 4. This is of particular interest in the Australian context, where 76.9% of the survey's participants indicated that their funding for prosthetic device was through either a state-based or national public provision scheme, which only provides a minimal rebate to cover the cost of a basic prosthetic hand. However, this is likely to be a key consideration in many other locations too. Traditional manufacturing methods with multiple actuators (i.e., motors) per digit make a highly functional prosthetic device unattainable to most recipients due to financial constraints. However, the combination of lower production costs due to additive manufacturing and lower actuator requirements resulting from an under actuated soft robotic approach, make the goal of an affordable highly functioning prosthetic more achievable.

4.6. Potential Future Implications

Due to the potential lower costs involved, a soft robotic and additive manufacturing could lead to a bigger variation in hands available for purchase and also provide the patient with the potential to afford multiple prosthetic devices. Our survey results indicate that the needs and desires of devices not only differ between users, but user needs can also change as life circumstances change. Potentially users could afford multiple devices to suit different needs in life, and easily change devices when life needs and/or circumstances change.

This approach could also lead to an expanded role of the occupational therapist and prosthetist in the building and adapting a hand to fit the user. Currently an occupational therapist helps a user determine the most suitable prosthetic device for the user and their needs, chosen from a small fixed number of models on the market. A prosthetist will then build a custom socket to fit the patient and the device, and the occupational therapist will help train them in their use. However, if a mass customisation approach is taken, more adaptability and customising is available to the prosthetic team. In addition, since additive manufacturing allows for relatively easy changes in design without significant additional production expenses, compared to traditional manufacturing, a potential future exists where the prosthetic team could alter a variety options; such as the hands shape, weight, size, colour; to help increase the comfort and acceptance of the hand for the user. In order to maximise this approach's success, it is imperative to involve prosthetists and occupational therapists in a discussion of their desires and needs for customisable options, so that the ability to change these features is built into any standard design.

4.7. Other areas of consideration for design

As shown in Figure 3, comfort is still a major priority for prosthetic users. Size and weight are the major contributors to this, as discussed in section 4.1. Although not a focus of this survey, previous results indicated that the actual socket to residual limb connection was a large source of skin irritation and discomfort [1, 4] and hence is another major contributor to overall comfort in prosthetic devices which requires further research and development. Osseo-integration [44] is one technique used to minimise the discomfort caused through socket interaction, whereby the socket is mechanically implanted into the bone of the residual limb. However, this is a highly invasive procedure and is not suitable for many upper limb amputees due to the unavailability of suitable bone anchorage.

Figure 4 demonstrates that durability is also a significant concern for users and it is directly associated with additive manufacturing and soft robotic approaches. Having the prosthetics completed in one print without post assembly [45] may contribute towards higher durability. In addition, if the cost is reduced, and manufacturing is able to be distributed (due to less complicated assembly) resulting in smaller repair times, this may also reduce the importance of this priority for the users. However, it is important to keep this priority in mind when designing current prostheses.

Although within each question it was of minimal significance, when examining the results as a whole, the desire for wrist flexion was a common recurrence throughout different questions in free text response from different participants. For the participants in our survey, it was seen as a key feature in improving the dexterity and usability of upper limb prosthetics.

5. Conclusion

This study has presented an insight into the experiences and desires of upper limb prosthesis users in Australia. The survey evidences a high need for an affordable, light weight dexterous prosthetic hand. These goals are difficult to achieve together using traditional manufacturing approaches. Using a soft robotic approach to prosthetic hand design resulting from additive manufacturing presents a pathway to help achieve a larger number of these goals simultaneously. In addition, it allows for the possibility of mass customisation, permitting individualisation of both size and appearance, which could increase the comfort of the prosthesis as well as lead towards a greater acceptance and utilisation of the device.

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