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Born or Built? Exploring visitor understandings of robotics

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Abstract

The *Born or Built? — Our Robotic Future* (*BOB?*) exhibition examines relationships between humans, robots and artificial intelligence. It encourages visitors to explore ethical and social issues surrounding these new technologies and invites visitors to post their own questions. We examine visitor responses to the exhibit "Q&A of the Day", which encourages visitors to engage by writing down their own question prompted by their experience in *BOB?*. As responses were submitted, it became apparent that the questions posed by visitors were potentially a valuable contribution to future science communication policy about robotics, and to those designing and implementing these technologies. We performed a content analysis that distilled themes in visitors' open-ended questioning that conveyed visitor knowledge and insight into what science communication about robotic technologies needs to address. Taken this way, visitors' questions form a moment of dialogue between the public and science communicators, engineers and researchers in which visitors contribute their knowledge and ideas about robotics. Such moments of dialogue are potentially valuable if the public is to be included in the development of robotics technology to build trust in robotics technology.

Introduction

Questacon — The National Science and Technology Centre in Australia developed the exhibition, *Born or Built? — Our Robotic Future* (*BOB?*) to encourage reflection on the impact of robotics and artificial intelligence (AI) on our lives and empower people to consider ethical issues surrounding their implementation. The exhibition brings together robotics and AI with some biotechnology to explore the idea that human bodies are becoming more constructed, and robots and AI are becoming more human-like. Visitors interact with robots and AI, and can respond to social and ethical questions about these technologies in interactive kiosks.

Several *BOB?* exhibits provide an opportunity to gather information about people's reflections on robotics and AI. Here we examine visitor responses to the exhibit "Q&A of the Day", which invites visitors to write down their own question prompted by their experience in *BOB?*. Although this exhibit was designed to engage visitors rather than gather information, it became apparent that answers posed by visitors were potentially a valuable contribution to knowledge about robotics, communicating the topics and questions relevant to robotics that science communication needs to address.[1] Participating visitors were intellectually and imaginatively focussed on robotics through their involvement with the exhibition. The responses were analysed to distil themes that might guide science communication policy about robotics and, even further, guide those designing and implementing robots as to public concerns and questions requiring consideration. Taken this way, visitors' questions went beyond fostering engagement in the exhibition to form a moment of two-way communication between the public and science communicators, and engineers and researchers. As such, we found that the questions indicated that visitors had a valuable a contribution to make to understanding needs in science communication concerning robotics and, more broadly, their surrounding social and ethical concerns.

Research on attitudes towards robotics in Australia tends to be focussed on specific professions such as nursing and social work [Papadopoulos, Koulouglioti and Ali, 2018] or institutional environments [Broadbent et al., 2012], rather than general public attitudes. Far more is known about public attitudes elsewhere, through mechanisms such as the "Eurobarometer Survey on Public Attitudes towards Robots" [Gnambs, 2019]. There has been limited research into what effective public engagement with robotics might look like, with the exception of research into the public's and researchers' ideas about public engagement in robotics conducted in the United Kingdom [Wilkinson, Bultitude and Dawson, 2011; Wilkinson, Dawson and Bultitude, 2012]. The understanding and insight provided by visitors in "Q&A of the Day" is valuable to Questacon, politicians, policy makers and industry in Australia, to guide future policy and research. Involving the public in building knowledge and future pathways of such technologies is a powerful means of increasing public trust in them and a vital aspect of their successful implementation [Dawson et al., 2019; Australian Centre for Robotic Vision, 2018].

Exhibition design

BOB? aims to encourage visitors to reflect on their perceptions of robots and AI, and how these technologies might become a greater part of their lives in the future. The design of the exhibition purposely does not explicitly answer the questions that it poses but offers context and information for visitors to think about and deliberate on them. The exhibition's objectives are to:

– highlight ways that humans and machines are becoming more similar;

– encourage visitors to think about the ways their lives are impacted by emerging technologies such as AI, genetic engineering, and human augmentation; and

– empower visitors to discuss the ethical uses of such technologies.

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[1]Science communication is used here in a broad sense, as including a range of skills, practices, discourses and media rather than in unidirectional sense that is contrasted with public engagement [Burns, O'Connor and Stocklmayer, 2003, p. 191].

The exhibition itself is an unstructured experience comprising an open-plan gallery containing 24 exhibits that encourage active participation. Visitors have plenty of opportunities for physical and dialogical interactivity, including with a variety of real robots and AI displays. The exhibits are grouped into three main themes: how robots are gaining skills we once thought unique to humans; how humans are increasingly programmable and replaceable; and, finally, our relationship with technology now and into the future. Displays are framed by open-ended, technical, social and philosophical questions about the future uses of robotics, AI and human modification, with some expert knowledge provided by information panels scattered through the exhibition. These include short animations about ideas relevant to the exhibition theme and interviews presenting the diverse perspectives of technologists, scientists, artists and philosophers. The gallery is divided by a series of kiosks in which visitors answer multiple-choice questions relating to the ontology, ethics and social implications of these technologies and statistics about their responses are displayed on a large screen. (For further details of the exhibition visit: https://www.questacon.edu.au/outreach/travelling-exhibitions/born-or-built.)

The exhibition continues a twentieth-century trend in science centre exhibits of focussing on the ethical and social context of science and technology in addition to demonstrating scientific principles of "hard" physics [Bell, 2008]. Rather than conveying a set of knowledge, it communicates important social and ethical problematics emerging in robotics and AI, and asks the visitor to reflect on them. Going beyond the idea that science communication is a one-way transfer of knowledge from experts to a lay public, the gallery's design creates space and opportunity for visitors to make meaning for themselves. The gallery incorporates design principles known to encourage visitor reflection: curiosity, narratives, challenge and interactivity [Skydsgaard, Møller Andersen and King, 2016, pp. 51–53; Gutwill, 2006]. The aim is to facilitate diverse and dialogic exchanges important to science communication [Trench, 2008]. Visitors bring diverse skill levels and social and cultural contexts to the gallery [Kerr, Cunningham-Burley and Tutton, 2007; Dawson, 2018], giving rise to reflections and responses that are not only valuable as demonstrations of visitor engagement, but potentially transformative of knowledge and practices in science communication and robotics in ways we discuss in more detail below.

"Q&A of the Day": eliciting visitors' understanding of robotics

There are several points in the exhibition at which visitors can contribute their views. This study examines that gathered via the exhibit titled "Q&A of the Day", which asks visitors to create their own questions about the topics in the exhibition.[2] Visitors write their own questions on a card and add them to a question wall. Each day before opening the gallery, a Visitor Services staff member selects a question submitted by a visitor and places it in front of a camera in the exhibit's base. The camera shows that question on a digital voting screen. Questions selected for the voting screen have binary answers (e.g. "yes/no" or "human/robot") and are chosen for their relevance to the exhibition content. Throughout the day visitors read the question and use the digital voting interface to choose their answer. Tallies are shown on a video screen for the selected question. The target audience for this

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[2]Other visitor contributions include the "Ethics Avenue" and "Ethics Wall" exhibits, in which visitors are asked to make choices on digital touchscreens about ethical questions or dilemmas, with data about visitors' choices displayed on a series of digital screens.

exhibit is visitors of reading/writing age, although younger children were encouraged to draw pictures on the question card if they could not write.

The exhibit asks visitors to submit questions with the aim of encouraging participation and reflection, and to encourage dialogue between visitors at different times. Over time, the richness in the ideas and themes expressed in the questions suggested to exhibition developers that the questions provided valuable insight into visitors' beliefs and reflections about robotics in particular. Moreover, they were providing a means by which visitors could articulate their own understandings of robotics, and what they thought were important social and ethical questions surrounding their implementation. Thus, the exhibit emerged as a potential site for visitors to speak back to Questacon to build knowledge about where science communication should prompt further dialogue and reflection. Staff speculated that this knowledge could not only guide more evidence-based policy in science communication about robotics, but also roboticists and engineers as to issues requiring attention in developing and implementing robotics.

In this way, "Q&A of the Day" could be transformed into a substantial instance of visitors contributing in a two-way communication process [Trench, 2008]. Our consideration of the exhibit's potential contribution coalesced around two questions: can prompting visitors' open-ended questioning in an exhibit elicit knowledge to guide science communication policy about robotics; and what insight into needs in science communication about robotics did visitor responses to this particular exhibit provide? In answering these questions, responses were not to be understood as demonstrating a deficit in visitor knowledge and understanding of robotics that needed to be addressed, or simply as providing insight into public attitudes. Instead, the point would be to see the questions as conveying visitors' knowledge, perspectives and values to science communicators, policy makers and researchers that might shape policy-making in science communication as well as research in science and technology itself [Irwin, 2014; Mohr, Raman and Gibbs, 2013; Irwin and Wynne, 1996]. Although the exhibit does not provide a forum for public deliberation and debate and thus limits participation, the aim of our research was to view visitors as "not just meant to act as information sources, but as citizens/members of the public with a right (and duty) to co-determine public policy- and decision-making on science and technology" [Joss, 1999, p. 291]. Consequently, our study pursues the idea that science communication can be a substantially dialogic and participatory process in which science communicators and researchers consult and listen to the public's understandings, perceptions and concerns [Metcalfe, 2019; Trench, 2008; Zorn et al., 2012].

Method

Questions and comments written on cards from the "Q&A of the Day" exhibit form the raw data for our analysis providing a cross-sectional convenience sample on which we performed a qualitative exploration of the Q&A answers using content analysis. This method was considered suitable due to the short nature of the relevant texts and the recurring themes within them. It is not considered to be exhaustive of the meanings in the questions. Visitors voluntarily wrote questions in response to the display prompt "Do you have a question?", under which blank cards and pencils were provided. Staff observed a range of visitors of reading/writing age and backgrounds participating in writing questions. Visitors pinned their responses up alongside other visitor submissions for the day and were

able to read existing questions. Staff monitored the wall to censor inappropriate material and remove and archive responses from the wall when space was needed. Staff were encouraged to interact with visitors, but only to stimulate the writing of questions. The exhibit was not staffed at all times.

The display invited visitors to submit a question about the exhibition to engage them in the exhibition. Questions were submitted on cardboard with no identifying information. One question was chosen each day to display on a wall. After a while, staff noticed that many interesting and unanticipated ideas and questions were being submitted. They thought the questions could provide valuable insight on an under-researched topic. The anonymous question cards accumulated over time, and those submitted in a three-month period were collected by gallery attendants and provided to researchers for analysis. A secondary analysis of the totally anonymous data, which did not require ethics approval, was undertaken.

Sorting of written responses

Visitors submitted a total of 10,037 questions between June and October 2019, which were examined and categorised into one of four groups: 1) valid, 2) off-topic, 3) silly, or 4) doodles (see Table 1 for category descriptions).[3] To categorise the responses, two human coders sorted and analysed an initial sample of questions from the dataset. The category criteria were mutually agreed upon between the coders. Once these criteria were established, a single coder categorised the remaining dataset.

Table 1. Question categories with explanations and frequencies of kinds of answers.

Question category	Frequency	Explanation
Valid	46%	Questions surrounding robots, AI and/or other future technologies
Off-topic	17%	Unfocused good-natured questions; comments or compliments of the centre
Silly	17%	Silly or provocative statements
Doodle	20%	Children's drawings; signatures; incoherent responses

The questions categorised as "valid" were subject to a text analysis that aimed to capture the perspectives of the texts' authors [Popping, 2015]. All valid questions were examined for the frequency of key words (semantic analysis), themes and specific questions. The frequency of specific words was analysed to interpret visitors' sense of agency regarding their future with robotics and AI, and the personal or collective focus of their reflections. To facilitate data analysis, two human coders used an initial sample of 100 questions to generate a set of themes. This pilot key was then validated using the questions 101–200, before finalising the list of themes that were used to code the remaining responses. This process ensured that codes were semantically valid due to our familiarity with the language of the responses and agreement between coders that the grouping of words reflected each category's meaning [Popping, 2015].[4]

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[3]In retrospect, we recognise that categorising some questions as not useful because they are "silly" or "irrelevant" can overlook the value of what has been described as "idiotic" responses to science communication, in particular they can allow for the questioning of "presuppositions that fed into... the practice of science communication" [Horst and Michael, 2011].

[4]We note that looking for commonality in responses limits insight into the heterogeneity and discontinuities of public understandings and ideas about robotics [Horst and Michael, 2011].

We also attempted to attribute the text to children or adults by examining handwriting style to guess at the adult status of the writer. We reasoned that neater, more evenly-spaced writing is the hallmark of an adult visitor and less organized script would be from children. This is an unsatisfactory method that leaves considerable room for error (a child of twelve might have adult-like handwriting), however, we nonetheless investigated the patterns emerging from this categorisation.

Results

During the period of the study, around 166,500 people visited the *BOB?* exhibition gallery. Previous unpublished data indicates that each visitor attends around half of the exhibits in any given gallery space, so an estimated 83,250 visitors would have attended the "Q&A of the Day" exhibit during the period of the study. From these visitors, 10,037 hand-written questions were submitted — a response rate of 12.1%. We have no data on the number of people who engaged with the exhibit but did not submit a question of their own. Such visitors may still have read, discussed or voted on others' questions. Of the 10,037 visitor questions, 46% were considered valid, 17% off-topic, 17% silly and 20% doodles, giving 4,658 valid responses. Therefore the valid response rate was $\sim 5.5\%$ of those visitors who likely attended the exhibit. There were 1,691 unique questions submitted, noting that some visitors asked more than one unique question. They included questions linking robots to broader media landscapes (for example, "will Shrek robot be real?" and "can robots play Minecraft?"), reflecting on human relationships with robots ("are robots better than people?" and "if a robot wanted to be your friend would you accept?"); speculating about killing or hurting robots ("can a robot be hurt?" and "is it good to kill robots?"); voicing fear for robots' future actions ("will a robot take my job?" and "will robots kill everyone in the world?"); and expressing curiosity about what they really are ("are robots made of metal?" and "are robots really real?"). The most common questions were "will robots take over the world?" (278) followed by "how do you make a robot?" (190), "how do robots work?" (100) and "why do we need robots?" (80) (Table 2).

Table 2. The ten most common questions submitted.

Question	Frequency (% of all questions)
Will robots take over the world?	278 (6.9)
How do you make a robot?	190 (4.7)
How do robots work?	100 (2.5)
Why do we need robots?	81 (2.0)
Do robots have feelings?	80 (2.0)
Who was the first person to build a robot?	43 (1.1)
Should robots have feelings?	41 (1.0)
Why do we make robots?	40 (1.0)
Should robots replace human jobs?	37 (0.9)
Will robots replace human jobs?	32 (0.8)

Common themes in responses

Our analysis identified twenty broad themes in the questions collected. Visitors most commonly wished to understand how robots are made and function (27.2% of

responses, Table 1). Visitors were also curious if robots could mimic human actions such as jumping, sneezing and talking (17.9% of responses). Many responses questioned how robots will affect human lives in the future and what place they will have within human society. A full list of these themes, with examples, can be found in Table 3.

Table 3. The twenty categories which questions were coded into, including demonstrative example questions and frequency of questions.

Category	Example questions	Frequency (% of questions)	Number of unique questions
to understand a robot	How do you make a robot? How do robots work? What is a robot?	1097 (27.2)	339
can robots mimic human actions	Can robots eat/dance/cook/talk/swim etc.? Do robots age/dream/play?	721 (17.9)	366
decisions regarding robots	Should robots have free will Should robots have rights? Who is responsible for a robot's actions?	612 (15.2)	253
place of robots in human society	Should robots replace teachers/babysitters/politicians etc.? Should robots live with human families? Should humans be allowed to date robots?	568 (14.1)	283
threat to humanity	Will robots take over the world? Will robots harm humans? Should we trust robots?	509 (12.6)	93
take over the world	Will/should/can/could robots take over the world?	383 (9.5)	21
what will robots replace	Should/will robots replace teachers/doctors/surgeons/pilots etc.?	309 (7.7)	127
robot feelings	Do/should/can robots have feelings? Can robots think? Can a robot have a personality?	242 (6.0)	88
visitor opinions regarding robots	Do you like robots? Would you trust a robot? Are robots better than humans?	217 (5.4)	88
what technology is to come	Do robots already exist? What will technology look like in the future? Will everyone be able to afford a robot?	213 (5.3)	117
effect of robots on humanity	Will robots replace human jobs? How will robots affect human lives? Will everyone be able to afford a robot?	187 (4.6)	61
benefit to humanity	Will/can/should robots help humans? Will robots do my chores?	165 (4.1)	100
why we need robots	Why do we need/make robots?	155 (3.8)	
genetic engineering	Would you allow robotic enhancements to your body? Should we genetically modify children? If I transplant my brain into a robot, am I still human?	98 (3.6)	98
history of robots	Who was the first person to build a robot? When was the first robot created? Where does the word robot come from?	92 (2.3)	28
AI	What laws should be made to regulate the production of AI? Is an AI responsible for its actions? Would you be okay with an AI using your data to learn how humans think?	92 (2.5)	92
human-robot comparisons	Are robots better than humans? How are robots different to humans? How do you know that someone is a robot?	76 (3.2)	76
miscellaneous	Would you eat lab-grown meat? Will we eventually have one language? Are we living in a simulation?	52 (0.0)	50
self-driving cars	Would you use a self-driving car? How will self-driving cars make decisions? Should human drivers be banned if self-driving cars are safer?	31 (0.9)	31
Questacon exhibit	When/why/how was this gallery built? How many robots are there at Questacon? How do the robots here look so real?	11 (0.4)	11

Choice of language

Our content analysis showed that most questions were about robots, with 90.9% of responses including the word "robot" or "robots" (Table 4). In comparison, only 2.4% of questions were about AI. The second and third most frequently used nouns were "human" and "world". These two words were generally used to ask how robots will affect a certain aspect of human life and their world.

Table 4. Top ten thematic groups of questions.

Theme	Frequency (% of questions)
to understand a robot	1097 (27.2)
can robots mimic human actions	721 (17.9)
decisions regarding robots	612 (15.2)
place of robots in human society	568 (14.1)
threat to humanity	509 (12.6)
take over the world	383 (9.5)
what will robots replace	309 (7.7)
robot feelings	242 (6.0)
visitor opinions regarding robots	217 (5.4)

The five most frequently used verbs were: "should", "do", "will", "can" and "how" (Table 5). About an equal number of questions asked "should" (19.5%) compared with "will" (19.4%). There were more asking "do" (25.1%) than "can" (14.7%). The distributions of verb and noun frequencies were consistent across the first half and second half of responses collected (Table 6).

Table 5. The words used in highest frequency in questions, not including determiners or prepositions such as a/to/the.

	Word	Frequency (% of questions)
Top 5 nouns	robot/s	3663 (90.9)
	human/s	687 (17.0)
	world	359 (8.9)
	feelings	178 (4.4)
	AI	97 (2.4)
Top 5 verbs	do	1010 (25.1)
	should	785 (19.5)
	will	780 (19.4)
	can	608 (15.1)
	how	591 (14.7)
Top 5 pronouns	you	570 (14.1)
	we	319 (7.9)
	who	94 (2.3)
	our	68 (1.7)
	your	53 (1.3)

Interestingly, personal ("me", "my", "I") pronouns were much less frequent than collective ("we", "us", "our") pronouns and "other" pronouns ("you", "your", "their") (Table 7).

Table 6. The difference verb and noun frequencies in the first and second half of response collection.

	Word	First half of response collection	Second half of response collection
Top 5 nouns	robot/s	1656 (89.6%)	2007 (91.9%)
	human/s	315 (17.0%)	372 (17.0%)
	world	174 (9.4%)	185 (8.5%)
	feelings	81 (4.4%)	97 (4.4%)
	AI	54 (2.9%)	43 (2.0%)
Top 5 verbs	do	392 (21.2%)	618 (28.3%)
	should	393 (21.3%)	392 (18.0%)
	will	364 (19.7%)	416 (19.1%)
	can	268 (14.5%)	340 (15.6%)
	how	266 (14.4%)	325 (14.9%)

Table 7. Frequencies of the different types of pronouns used in responses.

Group	Examples	Frequency (% of questions)
personal	me, my, I	58 (1.4)
collective	we, our, us	399 (9.9)
other	you, your, their, they	673 (16.7)

Discussion

We found that the exhibition engaged visitors in an exploration of the changing relationships between robots and humans. Their experiences in *BOB?* prompted some 5.5% of visitors to the exhibit to submit topically relevant written questions, reflecting practical, ethical and social issues about robotics. Our examination of these responses found them to convey visitors' understandings and concerns relating to robotics, generating useful knowledge for science communicators and, potentially, roboticists. Responses communicated ideas about how robots work, what they are capable of and significant ethical decisions surrounding their use. Importantly, the open-ended nature of the prompt in "Q&A of the Day" exhibit elicited unanticipated information about the knowledge visitors desired and what they thought warranted reflection. This kind of "really open-ended question" enables a diversity of answers (or in this case, further questions) and can capture alternative ideas [Popping, 2015]. Gathering information in the context of reflection-provoking interactive displays, we obtained a glimpse of the public's diverse knowledge, imagination and uncertainty surrounding the place of robots in our future.

Taking over the world

The most common responses recorded in our study echo common Western media portrayals of robots. This is consistent with informal findings during audience research and user testing for the exhibition development. Robotic revolt has been present since the inception of the term [Jones, 2017] and Western television and film have frequently portrayed "robopocalyptic scenarios" [Carpenter, 2016, p. 61]. Science communication frequently regards science fiction as an acceptable and effective means of appealing to the public [Davies et al., 2019; Menadue and Cheer, 2017]. To some extent, this exhibition continues this practice in its framing narrative of humans and robots converging to become indistinguishable, and thus

may have encouraged this response. However, the effectiveness of science fiction in communicating or encouraging engagement with robotics is questionable. Ideas about robots gained from science fiction can be a barrier to the acceptance of actual robots by generating unrealistic expectations or fear, even though it may facilitate their introduction [Weiss and Spiel, 2021, p. 6; Payr, 2019]. A popular dystopian image of robots and their role in society [Grazier and Cass, 2017] was mirrored in visitors' most frequently asked questions: "will robots take over the world?". More recently, television shows such as *Humans* [Vincent and Brackley, 2015–2018] and *Westworld* [Lewis, 2016–], have explored the possible places that robots will hold in our society. Other films, such as *Wall-E* [Stanton, 2008] and *Big Hero 6* [Roberts, Baird and Gerson, 2014] have portrayed robots in caring roles. This broadening out of ideas about robots' roles and relationships to humans is reflected in the second and third most common questions about robots: "will robots have feelings?" and "will robots replace human jobs?"

Capturing general themes of public interest of robotics

Our content analysis captured that in the context of the exhibition, the public were most interested in understanding robots. 59.2% of all questions were in the three themes: what robots are capable of, how robots will act and what place robots will hold in our society. Further, these were the three themes with the largest number of unique questions asked, revealing a diverse public interest and imagination surrounding robots.

We were able to very roughly divide the answers in this study into those coming from adults and those from children using handwriting style. While this method of separation is by no means robust, a contrast between answers attributed to our adult category and those ascribed to children emerged. Common questions categorised as from children asked if robots could imitate basic human actions such as sneezing, hugs, dancing and playing as friends. This demonstrates a tendency to anthropomorphise (attribute human traits to) robots, an inclination that is often effectively exploited in robotic design [Turkle, 2017], although not always successfully. Its prevalence in children would suggest a need to discuss the contrast between robots' appearance and capacities with young people, for example, draw attention to their inability to return emotions or experience suffering. Further, it supports the view that engineers and designers developing such robots need to evaluate the effects of anthropomorphising robots, particularly for children [Leong and Selinger, 2019]. This is a matter of ethics and of efficacy. Although anthropomorphism can work in favour of acceptance of robots, it can also cross ethical boundaries [Danaher, 2020] and encourage unrealistic expectations of robots that leads to disappointment [Dautenhahn, 2013].

Adults more commonly asked what jobs robots could take: which household chores they could perform and which professions they will replace. While there was united agreement that robots will replace occupations, there did not seem to be a shared view as to which ones. This conversation seems more to mirror the current climate of uncertainty surrounding what roles robots will fill [Borland and Coelli, 2017]. A 2014 survey of industry experts found that they disagreed in a similar way: 48% stating robots will replace blue- and white-collar jobs, while 52% expected that technology will not displace more jobs than it creates [Smith and

Anderson, 2014]. This uncertainty reflects the complex political, economic and social contexts that all shape the effects of automated technologies on employment [Autor, 2015]. The "Q&A of the Day" exhibit and our analysis captured that the public have both a good-natured interest in understanding robots, but also concern and uncertainty regarding the potential impacts of robots.

Characterizing the future by visitor questions

We observed that our visitors were undecided about whether they had influence over the future of robotics or whether robots would affect them personally. An equal number of visitors asked "should…?" versus "will…?". This difference in phrasing indicates opposing views: a choice over the matter versus inevitability of these developments. A central message of *BOB?* is that we have choice about the future implementation of robotics — that half of the responses indicated an awareness of this choice suggests that this point was successfully conveyed (although we have no baseline for comparison). Visitors did not share an expectation as to the timeframe for the widespread use of robots.

We observed that 16.7% of questions framed interest in "other" parties (you, they), compared to only 1.4% using personal pronouns (me, my) and 9.9% collective pronouns (we, our). Interestingly, it is possible that these results indicate a continuity in the Australian public's opinion: a longstanding unawareness or unwillingness to accept that technological changes will affect them personally [Eckersley, 1987]. The tensions and uncertainty expressed about robotic technologies could be relieved by more public communication about expectations and timeframes. While Australians continue to be optimistic about the capacity of technology to improve their lives [Bruce and Critchley, 2017], a lack of understanding of and participation in developing technologies can create public hesitancy, as has been seen with examples such as nuclear power and genetically modified crops [Cave et al., 2018]. This hesitancy can then impact uptake and delay public benefits achievable by technologies.

Robots versus AI

Our study indicates that Questacon's visitors are interested in understanding more about robots. We noticed that there were thirty times as many questions about robots than AI. This possibly relates to the lack of visibility of AI compared to robots, images of which are commonly circulated in literature and film even though few people regularly experience them. People are likely to experience AI in everyday technologies, but may not be aware that they are doing so [Lacerda Queiroz et al., 2021]. In addition, there is relative lack of visibility of AI compared to physical robots in the exhibition itself, in which the robot exhibits, such as "Uncanny Valley" and "Useless Machine," are more discernible than the AI specific content. The nature of creating an interactive hands-on exhibition with an expected 5 year life cycle tends to favour physical robotic interactions, which are easier to make robust, engaging and relevant for the full exhibition life cycle. Interactive AI exhibits date more quickly and *BOB?*'s AI content was more hidden in screen-based exhibits like "Emoji Translator" and the ethics kiosks, or more abstract interactions like "Making Faces". Improving communication with the public about AI technologies is further made more difficult because the industry

itself does not have a standard definition for AI [Musa Giuliano, 2020]. The lack of responses about AI in the context of this particular display is a prompt to reflect further on how to educate and engage the pubic regarding this increasingly widespread and rapidly developing technology. The results of our study suggest the importance of developing and presenting accurate and practical definitions of robotics and AI through education and science communication platforms, as well as clear discussions of the technical, social and ethical issues they raise.

Public trust and robots

The attainment of public trust is a key issue in the future development of robots [Australian Centre for Robotic Vision, 2018]. A key determinant of the public's willingness to cooperate with existing humanoid robots has been shown to be trust, for example, in security robots [van Pinxteren et al., 2019] and peacekeeping robots [Inbar and Meyer, 2019]. Although 22.1% of visitors asked whether robots are a threat to humanity or would take over the world, most visitors were open-minded and interested in the capabilities of robots. This degree of open-mindedness suggests a receptivity to public education about robots that would develop public trust and be in private and public stakeholders' best interests. As is the case with other technologies, the public is supportive when it is presented with the benefits of robotics rather than its disadvantages [for example, see Yu, 2020]. Our fifth most common question was "why do we need robots?". This question suggests a need for greater dialogue between organisations implementing robotics, and engineers and robot researchers, manufacturers and publics about the merits of robotics as well as the already extensive use of robotics in industry. Such dialogue would clarify the benefits of robotics in different contexts and mitigate against the assumption that robotics is always beneficial, provoking discussions as to how the benefits and burdens of robotics can be unevenly distributed across society [Rosenberg, 2008]. It could address concern for jobs and other social impacts, generating a sense that the public is participating in technological change rather than having it forced upon them.

Robots in society

That visitors' most frequent questions concerned the interaction of robots and humans is partly influenced by the widely visible, popular depiction of robots in literature, cinema and television. However, the content of the visitors' questions also indicates that they reflected on relationships between robots and humans and their implications. The social and ethical questions that visitors posed, such as "should humans be allowed to date robots?" and "should robots have rights?", shows some understanding of the dilemmas that face the robotics industry in modern society, understanding that that centres on parallels between humans and robots, a comparison that frames the exhibition.

The open-ended prompt of "Q&A of the Day" also provided valuable information about what the public wanted to know about robotics. A surprising result of the analysis was the high frequency of questions concerning the details of robot construction and function ("how do you make a robot?" and "how do robots work?" were the third and fourth most asked questions). While the gallery does address this issue briefly, it was of great interest to visitors and suggests that

difficult topics such as how robots work might be a bigger part of the public's understanding of this technology than we originally estimated. Educating the public about what robots are in practice would work against the dominance of the public imagination by images of robots from science fiction literature and films, which also tend to draw analogies between humans and robots [Payr, 2019].

Provoking visitors to consider the similarities between humans and machines captured visitors' attention, but our study suggests that this comparison hampers communication about the full extent of issues surrounding robotics. For example, adopting a logic of substitution places limits on our understanding of issues such as how robotics interacts with employment. Some research develops ways to think of robots as engaging in human-like activities but in new ways, and attempts to understand this difference [Sandry, 2015; Gunkel, 2012]. The frequency of the question "but how do they work" from visitors could be thought of as pointing towards the public's curiosity about this difference, that is, how certain behaviours are achieved in robots (and AI) in contrast to humans.

Limitations

Despite its advantages, the open interpretability of our prompt to visitors also limited the information gathered in this study. Our "Do you have a question?" prompt to visitors led to 54% of responses being irrelevant to our study aims. Nevertheless, it seems unlikely that a more direct question such as "do you have a question about robotics/future technology?" would have prevented the silly responses or doodles (together 38%). It certainly would have limited the scope of themes and topics discussed by visitors, resulting in less rich and unexpected information. Perhaps most importantly, direct questioning may have inhibited the role of the display in provoking visitors to unrestrictedly reflect on the themes of the gallery.

It is important to acknowledge that visitors to Questacon are not entirely representative of the wider public. Unpublished Questacon data shows visitors to the centre are mostly Australian, with 15% of visitors being from the local region, 83% from elsewhere in Australia (mostly NSW and Victoria), and 2% international visitors. We acknowledge that visitors largely self-select to visit our science and technology centre — perhaps indicating existing interest — although around 30% are in school groups where individual students do not control their own itinerary. Nonetheless, the study of this cohort was able to elicit questions from people who were intellectually and imaginatively engaged with ideas and experiences relating to robots and AI due to the surrounding interactive displays. As such, it contributes valuable information about public understanding of robotics in Australia, which plays a role in informing policy makers' decisions surrounding the development of guidelines, regulations and legislation [Australian Centre for Robotic Vision, 2018].

Finally, a lack of demographic data limited our analysis, and while we attempted to partially address this by roughly categorising answers by age, this method is not robust and only considers one demographic factor. Additional characteristics such as age, gender and postcode would allow for more in-depth analysis of Australians' understandings. Future studies would benefit from the collection of extra demographic factors from visitors.

Conclusions

The "Q&A of the Day" exhibit in *BOB?* was designed to engage visitors through open-ended questioning. We found, however, that it was also a means by which by which visitors could communicate their understanding of and insights into social and ethical problems surrounding the implementation of robotics. The analysis of the questions enabled the exhibit to become a substantially dialogic moment of science communication about what issues surrounding robotics require further dialogue. Visitors meaning-making in the exhibition went outside of what science communicators anticipated, suggesting different directions and problematics to be pursued. This can contribute to science communication policy-making and also guide those designing and implementing robotics technology.

The contribution visitors made through the exhibition was unplanned, and one further path to pursue would be to design and establish further exhibits to explicitly pursue research questions concerning science communication and other policy relating to robotics. This would enable more comprehensive contribution and analysis of ideas and knowledge provided by visitors, but potentially result in employing visitors in a more passive and controlled fashion. We note that while our use of deidentified, ad hoc data was within ethical guidelines, careful attention needs to be paid to ethical considerations surrounding such use of visitor comments. In future, the potential for comments gathered in displays to be used in research will be considered in the development of displays, so that respondents might be made aware of and consent to the use of comments in research. This would also allow for the collection of demographic data, like age, that could be used in analysis. Nevertheless, the ad hoc nature of the collection of comments can be seen as a valuable quality, minimising science communicators and researchers' control of what visitors might contribute, and creating room for unanticipated visitor understandings and ideas to become visible. The improvised and open nature of the inquiry suggests that science communication requires spaces for the unplanned and unexpected to occur in which publics can lead the way as to what constitutes valuable knowledge [Horst and Michael, 2011]. In this case, visitors contributed knowledge of robotics and surrounding issues, and informed our understanding of where guidance on science communication and technology policy can be found — in hand-written, open-ended questions.

Although not representative of the general public, visitors contributed their knowledge via the questions, pointing towards a series of issues requiring greater dialogue: how robots actually work; how real robots differ from science fiction ones; the purpose of robots; and the role of anthropomorphisation in robots. We note that dialogic moments of science communication can potentially be a point at which the public participates in developing new understandings of communication, decision-making and action that centre on machines rather than humans, meanings that take diverse public understanding, values and concerns into account. Enabling the public to contribute to policy-making in science communication about robotics, and to impact design and research in the field itself, will greatly strengthen trust and engagement in this technology. For, "anytime public engagement is defined, perceived, and implemented as a top-down persuasion campaign, then public trust is put at risk" [Nisbet and Scheufele, 2009, p. 1776]. Science centre exhibits can work as a mechanism by which publics are involved in shaping the future direction of these technologies, initiating and forming discourses surrounding them.

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