Social Robots Don't Do That: Exploring Robot-Typical Errors in Child-Robot Interaction

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ABSTRACT

Researchers have explored how robot errors affect people's perceptions of and interactions with robots. However, the types of robot errors that have been studied often reflect errors that humans tend to make, instead of those typically made by robots. In this paper we explore robot-typical errors, as opposed to human-like errors, spearheading a discussion on the kinds of mistakes we may face from robots. We specifically focus on child-robot interaction, and how robot-typical errors may occur in the presence of children.

KEYWORDS

Robot errors, human-robot interaction, child-robot interaction.

ACM Reference format:

Denise Y. Geiskkovitch and James E. Young. 2020. Social robots don't do that: Exploring robot-typical errors in child-robot interaction. In *Companion Proceedings of 2020 ACM International Conference on Human-Robot Interaction (HRI'20). ACM, Cambridge, UK, 2 pages.* https://doi.org/10.1145/3371382.3378295

1 Introduction

Research has explored how robotic errors may affect people's perceptions of a social robot, such as their trust towards it or following its instructions [8], how design (e.g., being personable) can compensate for errors [4], or how people may apply social constructs such as "cheating" to robot errors [9]. In many cases, research targets robots making human-typical errors, where a robot may make a relatable task error (e.g., doing things out of order), or simply get an object's name wrong [3]; these errors are often made in the context of otherwise-correct interactions. However, when interacting with real social robots in a natural scenario (e.g., in an airport instead of a Wizard of Oz research study), robots make errors of a fairly different nature. For example, they may have hardware malfunctions (e.g., overheating or motor issues), or speak or react in a way that highlights they generally have no social or contextual awareness (e.g., speaking to a person's reflection in a mirror, or treating somebody of smaller stature as a child). Although these errors result from technical problems, given the nature of social robots, we can expect people to interpret these errors from an anthropomorphic lens; especially children, who tend to perceive robots as being alive, and interact with them as social beings [7]. In this paper, we provide a discussion and initial framework for focusing on robot-typical errors in Human-Robot Interaction (HRI), especially within Child-Robot Interaction.

HRI '20 Companion, March 23–26, 2020, Cambridge, United Kingdom

ACM ISBN 978-1-4503-7057-8/20/03.
https://doi.org/10.1145/3371382.3378295

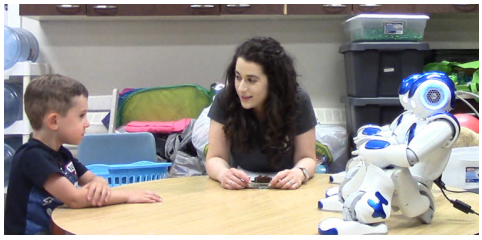

Fig 1. We explore children's reactions to robot errors, which can be quite different from errors people make (image used with parental consent).

2 Related Work

Robot errors have been explored in HRI under various contexts. Some research explored how a robot's human-like errors (e.g., making computational mistakes) tend to negatively affect perceptions of the robot (e.g., as less intelligent or reliable), but can also increase interaction satisfaction [6]. Others investigated how individuals responded to a robot that unexpectantly changed its response [9], was unable to complete the task it was designed for [4, 5], or provided clearly incorrect information [2, 3]. This research explored robots making human-typical errors, in the context of otherwise normal behavior.

However, few experiments have explored errors more representative of interactions with actual autonomous social robots, such as response delays [1], or irrational movements and contextually-strange requests [8]. We believe it is crucial to further understand realistic robot errors in HRI and their effects on people. In this paper we present an initial framework of robot-typical errors, when they may be observed, and a reflection of how they may be perceived by children; with the future goal to conduct studies with children to further develop the framework.

3 Framework of Robot-Typical Errors

Our framework considers issues stemming from low-level hardware and software malfunctions, all the way up to higher-level sensemaking and behavioral problems. Actions towards the top of the hierarchy (e.g., behavioral, see Fig 2) have the potential to make up for errors in the bottom (e.g., hardware errors), by having the robot adapt its actions in response to lower-level errors. This initial framework serves as a starting point for researchers, as it outlines the types of errors that children may encounter, and therefore need to be further researched.

3.1 Hardware Errors

Robot-typical hardware errors are those that occur due to broken or faulty physical components of the robot.

Faulty Computer – Faulty memory, processors, etc. will result in errors more typical of a PC than a person. The robot, for example, may suddenly freeze, or slow down its movements or speech.

Faulty Motors – Motors damaged or deteriorated from use, or overheating, may not move as intended. Motors may be disabled (e.g., failing to lift an arm), or move with a jitter due to movement compensation. The robot may make unpredictable movements from limited mobility or attempt to compensate by using other motors.

Faulty Sensors – Broken sensors such as regular or depth cameras, touch bumpers, microphones, etc., can lead to errors including a robot failing to respond to voice or other input, or acting inappropriately, such as bumping into people or walls while seemingly not noticing the error.

Children, who often anthropomorphize robots and see them as being alive, would possibly observe these hardware-related errors from a life-like perspective, with the robot moving and acting in ways not typical of living beings. Thus, this might lead to children viewing the robot as weird, funny (e.g., silly), or even scary.

3.2 Software Errors

Even if a robot has non-faulty hardware, errors can take place due to unexpected problems with the software, and therefore lead to outcomes different than those expected from the robot.

Software Crashes – Errors in the code, unexpected input types, or processing errors can cause the robot to have unrecoverable errors such as freezing or rebooting.

Program Bugs – Anomalies in the code can lead to non-catastrophic but inconsistent and unpredictable behavior. For example, a tutoring robot may provide different answers for the exact same math question.

Children who witness a social robot's software errors may believe it is acting strangely as compared to people, by freezing, rebooting, or acting inconsistently. This behavior would only be seen in humans who have health problems (e.g., heart attack), cognitive impairments (e.g., Alzheimer's), or with computers. Therefore, children who anthropomorphize the robot may view it as being ill or hurt, and in turn feel confused or sad for the robot.

3.3 Sensemaking Errors

Even if the hardware and software systems of a robot are error-free, higher-level errors in the robot making sense of that information can still occur.

Sensing Limitations – This includes a robot's inability to understand its location or environment, people or things around it, or what is taking place. A tutoring robot, for example, may continue to provide information after a child has finished a work problem, because it cannot sense that it was completed.

Misclassification error – Robots may erroneously classify beings, objects, and situations. A robot may therefore misclassify a child as a doll, misinterpret what a child says, or see children playing tag or wrestling and interpret it as an emergency situation.

Through an anthropomorphic lens, sensemaking errors may make the robot appear unintelligent, or perhaps silly and playful to children, since people tend to act this way when they misunderstand, have some sort of cognitive impairment, or are joking. Thus, these errors might lead children to believe that the robot is inadequate, funny, or has cognitive deficiencies.

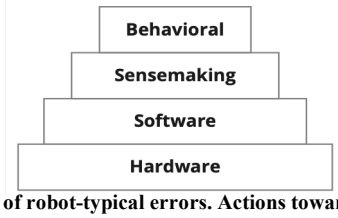

Fig 2. Hierarchy of robot-typical errors. Actions towards the top of the pyramid have the potential to compensate for lower errors.

3.4 Behavioral Errors

Given properly-functioning hardware, software, and sensemaking, a robot may still behave in a manner that is deemed inappropriate, either socially or contextually.

Nonsense or Lack of Response – A robot does not provide a response, or provides one that is either not related to the input received (even though sensors are working properly), or one that does not make sense. This may be due to the particular interaction not being coded for in the robot's behavior. For example, if a child asks a robot what an object is called, the robot may respond with a different and unrelated coded response (e.g., the day's weather, or no response) simply because it does not have other programming.

Failed Physical Attempt – The robot does not move as expected, or at all, regardless of all other components working properly. A robot might, for example, attempt to give a child a high-five, but fail to do so simply due to the complexity of the task, not any hardware, software, or sensemaking problems.

Context-Inappropriate Behavior – A robot may not behave in accordance to the social context that it is in. For example, a robot may ask a child to retrieve something from a high shelf, not realizing that it could be dangerous and the child could get injured, or it may tell a child an age-inappropriate joke.

As we can expect a child to anthropomorphize a robot's behavioral errors, they may perceive the robot as being inept, in terms of forming coherent speech, performing actions correctly, and behaving in an appropriate manner. These errors may therefore lead children to mistrust the robot's abilities, and view it as strange or having some type of illness.

4 Next Steps

Our initial framework of robot-typical errors highlights the types of malfunctions that social robots can have, and provides initial thoughts on how children may perceive them; children's perceptions are particularly important to study as children likely have little to no experience observing robot-typical errors, and tend to anthropomorphize robots. Future iterations of this framework will highlight the relationship between the types of errors; for example, a robot's behavior could compensate for other types of errors. In addition, targeted experiments are required to explore how children will actually respond to these errors. Here we provided an initial framework of robot-typical errors, and how they could affect child-robot interaction.

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