ware. Each component can be used separately or in any combination. Each system component will be compatible with off-the-shelf software, switches, and sensors. The system will be available to schools, rehabilitation facilities, educators, clinicians, and the general public. Partnerships with existing product developers will enhance and strengthen the capabilities of the CosmoBot system. At AnthroTronix, we believe that children with disabilities should participate in inclusive education environments and that assistive technology is inclusive technology.

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Robotic Products to Assist the Aging Population

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WHEN MR. AND MRS. G MOVED to a new one-bedroom apartment in an elder high rise, they were dismayed to that the previous tenant had installed grab bars in the bathroom. "We didn't think we needed them. After all, we were a young couple in our 70s. It wasn't long before we realized it was a blessing to have them. They are really helpful for getting out of the bathtub and off the toilet." It was only through direct experience of the grab bars that they could make sense of this assistive product, let alone acknowledge its utility.

The United States is currently witnessing a rapid increase in the number of elderly people. The U.S. Census estimates that there will be about 12 million people over age 85 in 2040 [7]. Many are expected to need physical and cognitive assistance. The greatest need for assistance comes from elders who live independently in their home. Nursing homes already suffer from significant space and staff shortages.

Technological advances are being directed to assist the senior population and those who provide care. These products, which can be charted in the assistive robotics literature, emphasize the independence of the elderly as a primary goal. They provide support for a range of basic activities, including eating, bathing, dressing, and toileting. They sup-

port mobility in the form of ambulation assistance and rehabilitation. They provide household maintenance in the form of monitoring and maintaining safety in particular environments [4]. However, many of these products have been designed with little consideration of the social, aesthetic, and emotional relationships that the elder (and community of users) will form with the product. Instead of supporting the elder's quality of life, many instead highlight the disabilities of their users and are stigmatizing. Future assistive robotic products need to move beyond task-based interactions, and be attractive, affordable, and non-stigmatizing. Accessibility, ease of use, and reliability are particularly important for this population.

How might robotic technology be best used to assist the aging population and those who provide care? Our research group, the Project on People and Robots [5], has been researching how robotic technology can be used to assist elders, caregivers, and others in the workforce. Our group of designers, social scientists, and roboticists are working to discover what robots should do, how they should appear and interact with people, and how people make sense of unfamiliar new technologies.

Figure 1. Images from an ethnography of elders living independently in their homes in two Midwestern cities

Will it Fit in the Living Room? The domestic environment is receiving attention as a place for the development of robotic technologies. Appropriately designed technologies have the potential to greatly benefit all of humankind. There are significant technical and interaction challenges in the home. There are also many human needs, in the form of specialized user groups including the elderly, the mentally impaired and the disabled, that require us to be sensitive to social and cultural values of those we are trying to support. Finally, the home has a long relationship with aesthetics in the choice of what to use and display.

The intersection of elders, the home, and rehabilitative robotics revealed several opportunities for our research. We have focused on the home as a growing area of need. Many debilitating accidents happen to the elderly and infirm while unattended at home [3]. In addition, the home becomes a central place for the aging population until finally it subsumes all activities (Figure 1). We conducted an ethnographic study of elders and caregivers in two Midwestern cities that focused on elders' relationships with products [1]. By understanding elders' current relationships with products, we will best be able to understand how to supplant breakdowns with robotic technology.

We have described the experience of aging and providing care as an ecology of aging. This term describes the complex interactions between people, products, activities, and resulting experiences that take place in an elder's local community. Components of the ecology are adaptive. If one part breaks down, another will compensate. For example, if an elder can no longer drive, she will either make fewer trips, rely on family or friends, or hire

a taxi service. Components of the ecology have complex information flow. For example, consider the communication between an elder, her physician, her family who needs to monitor her diagnosis, and her pharmacy. Components of the ecology are dynamic and have the potential to break down. For example, in response to a crisis such as a broken hip, an elder's family needs to put a temporary response in place. Often, due to lack of resources, the temporary response becomes a permanent response, against the elder's wishes and at great cost to the family.

Will a Robot Replace Me at Work? Robots remain a fairly uncommon technology in the everyday world. Many people draw their ideas about robots from images in popular culture and science fiction, or from limited knowledge of robotic capabilities. As robots are deployed in home and work settings, designers will need to take into aspects of social experience that people will use to understand and interact with the technology.

Sensemaking is a social process through which people make sense of situations and events [8]. Sensemaking happens when people invoke various perceptive activities that actively direct an individual's cognitive processes, including what to attend to and how to interpret information [2]. The novel and unexpected can draw people from automatic processing into instead noticing what is going on around them. Technology is subject to the same processes of meaning as other elements in the environment. We can expect, then, that the introduction of an assistive robot into the workplace might cause sensemaking to occur.

We studied the process of sensemaking over a period of time when a mobile autonomous pharmacy robot was introduced into a hospital environment, in order to witness the process of sensemaking about the technology within an organization [6]. We learned that sex segregation structures may have had an impact on how men and women, segregated into distinct jobs at the hospital, made sense of this new technology. Positions in the hospital also contributed to how people engaged in sensemaking. Engineers and male administrators generally saw the robot as a machine they could control; female administrators and low-level staff anthropomorphized the robot as a human male that acted with agency, and nurses saw the robot as a technology with little work utility.

The results of these research efforts are being used to generate knowledge to assist the design of future robotic technology. The ecology of aging allows us to formulate and test solutions, while continually deepening our definition of the design problem. Sensemaking shows that technology is not the only influence in designing new products—social dynamics, economics, and environmental issues also play an important role.

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