Prior-to-request and request behaviors within elderly day care: Implications for developing service robots for use in multiparty settings

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Abstract. The rapidly expanding elderly population in Japan and other industrialized countries has posed an enormous challenge to the systems of healthcare that serve elderly citizens. This study examines naturally occurring interaction within elderly day care in Japan, and discusses the implications for developing robotic systems that can provide service in elderly care contexts. The interaction analysis focuses on prior-to-request and request behaviors involving elderly visitors and caregivers in multiparty settings. In particular, it delineates the ways caregivers' displays of availability affects elderly visitors' behavior prior to initiating a request, revealing that visitors observe caregivers prior to initiating a request, and initiation is contingent upon caregivers' displayed availability. The findings are discussed in relation to our work in designing an autonomous and remote-controlled robotic system that can be employed in elderly day care centers and other service contexts.

Introduction

The rapidly expanding elderly population in Japan and other industrialized countries has posed an enormous challenge to the systems of health care that serve aging citizens. The field of robotics, in particular the development of service robots that can provide various forms of care, poses promises and challenges. Recent advances in robotics have led to the development of robots that can interact with people in public settings. For example, researchers have developed both autonomous (e.g. Imai et al. 2000) and remotely controlled robots that support human-to-human communication (Paulos et al. 1998; Jouppi et al. 2002; Kuzuoka et al. 2004). Such trends have led to an exploration of Human-Robot Interaction (HRI) and Robot-Supported Cooperative Work (RSCW) (Machino et al. 2006).

Several of the present authors have also been developing human-assisting robots through collaboration between robotics engineers and human interaction sociologists. We have discovered that seemingly mundane actions that occur between humans are not easily implemented in robots for human-robot interaction. One category of such actions is request-grant pairs. In order to provide service in contexts such as elderly care, robots need to be able to recognize human behaviors that require assistance, and then carry out assistance either autonomously or with the help of a human caregiver. While several of the authors have recently collaborated in the development of a robot that can approach a person who makes a summons by waving a hand (Miyauchi et al. 2004), we have not yet designed a robot that can respond to a person's request through hand waving or other semiotic means within natural settings.

In order to begin to address this issue, we have been examining human-human interaction within elderly day care facilities in Japan with a focus on verbal and non-verbal behaviors surrounding requests. This paper focuses on pre-request and request behaviors in order to show how visitors select a particular caregiver, and how caregivers acknowledge and grant a request. These findings are then discussed in relation to our work in developing an autonomous and remote-controlled robotic system that can be employed in elderly day care and other service contexts.

Background

Through the collaborative efforts of robotics engineers and human interaction sociologists, we have been working towards developing a robotic system that can provide 'service' within elderly day care facilities. Due to a rapidly expanding elderly population in Japan and other industrialized countries, elderly care has become a critical social issue, and robots are considered a means of providing a partial solution. In order to undercover the potentialities of robots for use in elderly day care, as a first step we video-taped interaction in three elderly day care centers in Japan. In Japan, people who provide elderly day care service include nurses, assistants, and part-time volunteers, all of whom will be referred to here as 'caregiver'. Japanese day care facilities typically support elderly persons in routine, everyday activities such as bathing, eating, and playing games. In the centers we observed caregivers often circulate around the room in order to monitor visitors who might need assistance (e.g. getting a drink, going to the bathroom). That is, multiple caregivers and multiple visitors are co-present in the same room, and any caregiver may provide assistance to any visitor.

In analyzing interaction, we focused on behaviors surrounding requests, including the initiation of requests by visitors and the granting of requests by caregivers. Our initial observations can be characterized as follows:

(1) Among multiple caregivers and visitors, requests occur within a context in which multiple tasks are managed simultaneously.

(2) When a visitor requires assistance, the visitor makes verbal and non-verbal actions before initiating a request.

(3) Since multiple parties are engaged in different kinds of tasks, a visitor may seek out an available caregiver, establish a channel to communicate, and then initiate a request.

These initial observations raise several questions. How do visitors search for a caregiver among several caregivers in the room, choose a specific one, and then create a one-to-one connection with a particular caregiver?

Interaction analysis

Interaction analysis by C. Goodwin, C. Heath, G. Lerner, and others has revealed the importance of gaze and bodily posture at the initiating stage of a request or other social action. For example, Goodwin (1981) and Heath (1984) have shown that hearer gaze and bodily orientation relate to a speaker starting or re-starting talk. Lerner (2003) has observed that a present speaker's selection of a next speaker is highly related to the present speaker's gaze direction. For example, when a present speaker begins making a request towards a potential recipient the speaker gazes towards that recipient.

In this paper, we focus on prior-to-request and request behaviors among elderly visitors and caregivers. In relation to this, Heath (1984) makes a distinction between 'display of availability' and 'display of recipiency': '…whereas a *display of availability* serves as a pre-initiating activity providing an environment for the occurrence of a range of actions, a *display of recipiency* specifically initiates a sequence' (p. 250). In our data, caregivers typically displayed availability to multiple recipients (visitors) and then displayed recipiency to a particular recipient (visitor) before the visitor made the request as will be explicated below.

Lerner (2003) has pointed out that gaze has limitations as a tool for selecting next speaker. That is, the speaker's gaze is effective only when the recipient can see the speaker's gaze. In our data, visitors who displayed that they wanted to make a request to a caregiver typically first observed whether or not the caregiver was displaying availability or recipiency by gazing towards the caregiver before making the request. These initial observations led to the formulation of five central questions.

- Q1 How do caregivers display availability to visitors?
- Q2 How do caregivers display recipiency to a visitor?
- Q3 How do visitors behave prior to making a request to a caregiver?
- Q4 How do visitors behave when a caregiver is not displaying availability and/or recipiency?
- Q5 How do visitors and caregivers display acknowledgment that establishes a connection for initiating requests?

Setting and methods

Ethnographic observations and videotaped recordings were made at three elderly day care centers in Japan. Day care center 1 is a mid-size facility located in a rural area of Western Japan. At this center we videotaped approximately fifteen hours over three days with two fixed cameras and two handy cameras. Day care facility 2 is a mid-size facility located in a suburb of Tokyo. At this center we videotaped approximately five hours with two fixed video cameras and three handy cameras. Day care facility 3 is a small facility in a suburb of Tokyo. At this center we videotaped approximately five hours with three fixed cameras. At each of these centers we set the fixed cameras on an overview of the main room, which allowed us to film from various angles. We videotaped using multiple cameras in order to capture gaze, bodily actions, and the use of objects. We had several caregivers wear a wireless microphone, and we used both remote microphones and directional microphones in order to record clear sound.

Behavior of caregivers

Caregivers display availability to visitors in various ways. Figures 1 and 2 show a lunch scene at facility 1. Caregiver F is circulating among the tables while looking around at the participants who are eating lunch (Fig. 1). The caregiver displays availability towards multiple visitors through bodily posture, head turning, and gaze. When F momentarily faces towards visitor G, visitor G lifts up a packet of medicine (a pre-request for the caregiver to open the packet for him) (Fig. 2), to which caregiver F responds by saying 'Yes' (*hai*) while approaching G.

Figure 1. F displays availability to visitors. Figure 2. F displays recipiency to G.

As indicated in these figures the caregiver distributes her gaze and bodily posture in such a way so as to display availability to multiple visitors. When the caregiver momentarily faces a specific visitor, the visitor ceases the split second to hold up the medicine, which results in his gaining the caregiver's recipiency.

Figure 3. D not displaying availability towards C.

In the previous example, display of availability was done through bodily posture and gaze direction. In displaying availability it seems crucial that the caregiver is (at least partially) facing towards the visitor. A visitor may delay initiating a summons or other pre-request actions until a caregiver is facing him or her. For instance, in the next example (also from facility 1), visitor C has just finished taking a bath and is sitting down at a large table with several other visitors. When visitor C gazes towards caregiver D, caregiver D is facing the opposite direction, with her back turned walking away from C (Fig. 3). Although caregiver D is currently circulating around the room monitoring what visitors are doing (and consequently displaying availability to them), at this moment she is facing in the opposite direction of visitor C. Visitor C then begins looking around the room for another caregiver.

This section has shown ways that caregivers display availability and recipiency, and suggests that visitors' initiation of requests is contingent upon displays of availability and recipiency. The next section focuses more centrally on the behavior of visitors, in particular comparing cases when a caregiver is displaying availability and when a caregiver is not displaying availability.

Behavior of visitors

When caregiver is displaying availability

This section focuses on what visitors do prior to issuing a request when a caregiver is displaying availability. In such a situation, we find two crucial behaviors. First, visitors often monitor through gaze what a caregiver is doing. Such gaze allows the visitor to seize a moment that a caregiver is displaying availability towards a visitor who has a request. Second, visitors initiate requests after gaining recipiency, waiting until a caregiver faces towards him or her before initiating a request.

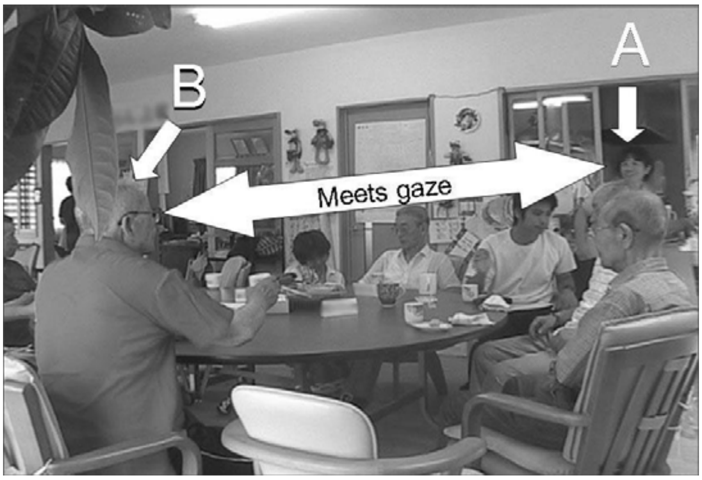

Figure 4. A begins to lift teapot while gazing towards B who then lifts up his teacup.

[Data1] Facility 3 07/22/05 [10:09am]

01A[gaze] : ,,,,,----------,,,,,,----------,,,,,,,

↑(Cups on the table)

A[action] : (Walks to teapot at back counter)

B[gaze] : A----------------------------,,,,,

02A : (nod and lifts arm)

A[gaze] : ,,,Bxxxxx,,,,,,,,,,,

A[action] : Walks to A's seat ,,,, Puts A's cup,,,,,Walks towards teapot ,,,,,,

B : *a* *hhhhhhh*

'Ah' hhhhhhh

B[gaze] : ----------------------,,,,,,A------------,,,,----------------,,,,,A---xxxxxx-----------
↑(To entrance) ↑(To B's cup)
B[action] : Raises B's cup to A

Transcription conventions:
,,,, (movement of gaze, not fixed towards anything specific), A---(gaze fixed towards A; ↑ below indicates gaze is fixed on an object), underline (contextual explanation), italics (Japanese), h (laughter tokens).

The above points are illustrated in Data 1. This example comes from a scene in which visitors and caregivers are seated around tables having tea. The transcript begins at the point when caregiver A stands up and goes towards the teapot at the back counter (Fig. 4).

In line 1, visitor B is looking towards caregiver A, who is looking at the cups on the table while walking towards the teapot at the back counter. After caregiver A reaches for the teapot and pours her own tea, visitor B stops looking towards caregiver A. In line 2, visitor B again looks towards caregiver A just as A walks towards her own seat and puts down her cup on the table. When caregiver A starts lifting up the teapot and gazes towards visitor B, visitor B lifts up his cup towards caregiver A, and A responds by nodding and lifting her arm slightly, and then bringing the teapot to B to pour him more tea.

In this example, visitor B first gazes towards caregiver A as A looks at others' cups on the table, displaying an intention to serve more tea. Visitor B's continuous gaze towards caregiver A allows him to seize a brief moment him to lift up his teacup when the caregiver gazes towards him. In this way a visitor can initiate a non-verbal action, which in this case is interpreted as a request, at a brief moment when the caregiver displays recipiency towards the visitor.

The next excerpt illustrates how visitors behave when a caregiver displays availability but does not display recipiency. In Data 2, visitor H is seated around a table with other visitors engaged in coloring pictures. Visitor H observes caregiver K passing by while lifting her picture slightly, which displays some trouble with coloring the picture. Through caregiver K walks towards visitor H, he does not direct his gaze towards H (Fig. 5). In other words, at this moment K displays availability (visitor H is nearby and likely within K's peripheral vision) but does not display recipiency towards H. K then stops at the desk of another caregiver (J) and begins to address this caregiver (Fig. 6).

Figure 5. Caregiver K walks towards visitor H. Figure 6. K addresses caregiver H.

[Data2] Facility 2 06/12/27 [10:07am]

K : *suimasen cho*[*tto* *hai*
‘Excuse me a bit’ ‘Yes’
K[gaze] : ,,,J---,,,,,,,,,,H-----------------
K[action] : ,,,Stops walking, walks to J Turns to H
H : [*sensei kore dooyotte*
‘Sir, what do you think about this?’
H[gaze] : ,,,K---
H[action] : Prepares to show her picture to K

As K begins to address caregiver J, visitor H immediately interrupts K’s talk using the addressee term, ‘Sir’ (*sensei*). Following this term of address, caregiver K turns his head towards visitor H and H then initiates a request, ‘What do you think about this?’

As we can see in this data, a visitor may attempt to gain a nearby caregiver’s recipiency to initiate a request when the caregiver is engaged in concurrent talk with another. The visitor then initiates her request upon gaining the caregiver’s recipiency.

This section has examined the behavior of visitors when a caregiver is displaying availability, and either is or is not displaying recipiency. The next section will examine visitor behavior when a caregiver is not displaying availability.

When caregiver is not displaying availability

This section considers cases in which a caregiver is not displaying availability. In such a situation, a visitor who has a request does extra work in order to gain the caregiver’s availability. We will show two points here. First, a visitor often displays a need for assistance by looking around to determine which caregiver is available. Second, a visitor may gain other visitors’ help in achieving a caregiver’s availability.

Let us examine the first point. By continuously looking around and searching for a person, visitors may attempt to locate an available caregiver who is relatively far away. This is illustrated in Data 3. Prior to this interaction (as discussed earlier in relation to Figure 3), visitor C had just finished taking a bath and is sitting down at a table. Visitor C continuously looks around but fails to locate a caregiver displaying availability towards her. After some time she locates caregiver E who is a bit far from her. Visitor C then waves her hand, as a non-verbal summons, towards caregiver E who then approaches her (Fig. 7). When caregiver E arrives at visitor C's table, C makes a request.

Figure 7. Elderly visitor raises her hand towards caregiver who is far away.

[Data 3] Facility 1 07/02/15 [11:12am]

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C           :                        furo kara agatta kara karupisu cho::dai
                                     'I've gotten out of the bath, so get me a Calpis drink.'
C[gaze]     : E--xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
C[action]   :     Waving her hand towards E.
E           :                        doshita                        yossha wakatta
                                     'What happened?'               'Okay'
E[gaze]     : ,,,Cxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
E[action]   :       Runs towards C
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As can be seen in this data when there is no caregiver displaying availability a visitor may search for a caregiver until locating a caregiver who is displaying availability. When an available caregiver is far away, a visitor may summons a caregiver using non-verbal means.

We now examine the second point. In some cases, visitors engage in pre-sequences with other visitors to establish the legitimacy of a request when they do not identify a caregiver displaying availability. In the following example, visitor A notices that there is no footrest while sitting down at a table with other visitors (line 1). While this trouble report receives other visitor's agreement (line 4), it is not noticed by caregiver E who is currently talking to other visitors at the adjacent table. After other visitors agree with the trouble (lines 7 and 8), visitor A initiates a request towards the caregiver who is next to their table (line 12) (Fig. 9).

Figure 8. Talking about a missing footrest.

Figure 9. Initiating a request.

[Data4] Facility 2 06/12/27 [11:13am]

01A : *Ara mo::o okashi:to omottara, kyoo ashi ga nainda ne*?
‘Oh I was thinking something is wrong today, there aren’t any feet, right?’
02B : e?
‘What?’
03A : *ashi* ↑ =
‘Feet?’
04C : *aa::: a*[*shi*.
‘Oh , the feet (=footrest).’
05D : *aa*:::
‘Ah:::’
06A : *Are na::nka ashi ga darui to omotta*[*ra*.
‘I was thinking my legs feel a bit tired.’
07B : [*un*.]
‘Yeah.’
08C : *Dokonimo nai desu*[*ne*:::::
‘I don’t see it (=the footrest) anywhere, right:::::.’
09A : [*Nee* (*itsumo atta-*)
‘Yeah. (They [=the footrests] are always there-)’
A[gaze] : C--,,,,,E---------------------
10C : *Wasurechyatta*[*nokana*
‘Maybe they (=the caregivers) forgot it?’
11A : [*Dasete moraoka*.
‘Should we have them bring it?’
A[gaze] : E------,,,,,C and B----------------------
12 (0.3)
13A : *Ne*:: ↑ ::: ↓ *chotto* *nee* *suima*[*sen* *kashite kuremasu ka*
‘Hey, a bit hey excuse me Can we borrow?’
A[gaze] : ,,,,,E---------------------,,,,,,,,EXXXXXXXXXXXXXXXXXXXX
A[action] : (turning her body toward left, facing toward E)
14D[gaze] : ,,,,,,,,,,,,,,A-----,,,,,,E-------,,,,,A-------
D[action] : (touching E’s arm Pointing at A)
15E : [*Hai*?
[‘Yes?’
E[gaze] : ,,,D---,,,A--------,,,,,,, ,
E[action] : (coming close toward A) (putting her face toward A’s ear)

In this example, visitor A does two crucial things prior to making her verbal request. First, she establishes the legitimacy of the request by talking to other visitors. In line 1, she notices that there is no footrest. After other visitors also recognize the problem (line 4 and 5), she gives an account for why she noticed the problem by mentioning her tired legs (line 6). Visitor C agrees with the problem (line 8) and provides an account saying, 'Maybe they (=the caregivers) forgot it?' (line 10). By engaging in this talk, visitor A is able to confirm the legitimacy of the problem and gain other visitors' support for initiating the request.

Second, prior to making the verbal request, visitor A achieves the caregiver's recipiency with the assistance of visitor D. In particular, as visitor A utters a summons towards caregiver E (line 13) (Fig. 9), visitor D starts looking towards caregiver E. When caregiver E does not respond to visitor A's verbal summons, visitor D touches caregiver E's arm and points at visitor A. This directly assists visitor A's initiation of the request. In line 13, visitor A makes a request to the caregiver.

In summary, this section has shown what visitors might do when they need a nearby caregiver's assistance but the caregiver is not displaying availability. The final section of the interactional analysis reviews the above analysis in relation to displays of acknowledgment.

Displays of acknowledgment

This section describes displays of acknowledgment in relation to establishing a connection for initiating a request. It specifically focuses on what caregivers do in response to a visitor after a visitor indicates a need for assistance. We found the following four patterns in caregivers' behavior in relation to visitors who had requests, and explicate these by reiterating data previously discussed.

(1) When a caregiver displays both availability and recipiency towards a visitor, the caregiver responds to the visitor with a minimal utterance and/or non-verbal action, and then approaches the visitor. In Figure 2, when the visitor catches the caregiver's gaze, the caregiver responds by saying 'Yes' and then quickly approaches the visitor. In Data 1, when the caregiver caught the visitor's gaze, the caregiver responded by nodding towards the visitor and then brought the teapot to the visitor to pour the visitor more tea.

(2) When a caregiver displays availability but does not display recipiency (as he or she is engaged in a concurrent activity), the visitor may interrupt the caregiver's activity; the caregiver may then respond by directing his or her attention towards the visitor and then verbally responding. In Data 2, following the visitor's summons, the caregiver turned his head towards the visitor and then responded by saying 'Yes'.

(3) When a visitor does not locate any caregiver displaying availability, the visitor may search for a caregiver until locating one, and then wave his or her hand to call for the caregiver; the caregiver may then move quickly towards the visitor and verbally respond. In Data 3, upon locating an available caregiver, the visitor waved her hand, and then the caregiver hurried to the visitor and initiated the question, 'What happened?'

(4) When a visitor requires another visitor's support in accomplishing a request (such as when a caregiver is nearby but not displaying availability towards a visitor who needs assistance), the caregiver attempts to respond to the visitor who gave help first and then displays recipiency towards the visitor who then grants the request. In Data 4, when the visitor attempted but failed to summons the caregiver, another visitor summoned the caregiver by touching the caregiver's arm on behalf of the visitor who initially needed assistance. The caregiver stopped her immediate engagement with other visitors, and then brought her body posture and face towards the visitor who touched her arm, saying 'Yes'.

This section has discussed caregiver acknowledgment of visitors' prior-to-request and request behaviors, which are done through verbal and/or non-verbal means (e.g. rushing to the visitor, nodding, saying 'Yes').

The preceding analysis suggests that visitors' and caregivers' behaviors prior to requests play a crucial role in carrying out requests within elderly day care centers in which multiple parties are co-present. The next section applies this analysis to a discussion of our work in developing robotic systems that have the potential to be employed in the service of elderly care.

Towards development of a service robot

Three-step approach

In relating the above findings to developing service robots for use in elderly care, it will be helpful to review our overall approach, one that we have taken in developing robots for use in other multiparty settings (Kuno et al. 2007). The first step, as indicated in the previous section, is to analyze human-human interaction through interaction analysis, in particular the non-verbal and verbal resources that participants use in carrying out action. The second step is to consider the findings in relation to developing a robotic system that can provide particular types of service (e.g. responding to visitors' requests). The third step is to examine how humans and the robot interact, and then evaluate the effectiveness of the robot in order to refine it. This approach helps clarify in what ways human-like interaction may be accepted and preferred, and in what ways it may be possible to employ robot caregivers alongside human caregivers. It should be noted that our research is not aimed at developing robots that can replicate human-human interaction, but rather is aimed at developing robots that can be 'user friendly.' Towards this end, we consider both cognition and action in design, including what types of verbal and non-verbal actions that we need to have robots do, and what types of verbal and non-verbal actions we need to have robots recognize in humans.

This section discusses our developments in relation to the second step: considering the findings from the interactional analysis in relation to the design of a robotic system that can be employed in multiparty elderly day care settings. The analysis of human-human interaction suggests that we should consider the following four issues. The related questions that these address were presented earlier and are shown here in parentheses.

(1) Display of availability: A service robot should be able to circulate among visitors engaged in activities and effectively display availability to them. (Q1, Q3)

(2) Display of recipiency: Following a visitor's verbal and/or non-verbal actions indicating that assistance is required, the robot should be able to display recipiency through gaze, and head and body orientation. (Q2, Q3)

(3) While (1) and (2) apply to typical situations, as suggested in Data 2 and 4 the robot should be able to deal with alternative situations such as when a visitor is in need of assistance when the robot is not displaying availability (e.g. engaged in another task). In such cases, the robot should be able to determine the priority between its current task and the new task. The robot should then be able to either signal a delay or immediately attend to the new task. (Q4)

(4) Acknowledgment: The robot should be able to recognize the reaction of the visitor against the robot's display of recipiency, and judge if the visitor is calling for the robot's help. The robot should then display acknowledgment, such as saying 'Yes' or raising its hand (Q5)

In order to address these issues, we have been developing two robotic systems. One is an autonomous robot and the other is a remote-controlled robot. The autonomous robot does not currently have high capabilities for responding to many of the problems and needs that arise within elderly day care centers. In such cases, it is imperative for the robot to be able to change to remote-control mode and let a remote caregiver respond to the problem. Since a remote caregiver only has to deal in person with the robot that cannot respond to a problem on its own, the remote caregiver can oversee several robots simultaneously. We are working towards this and expect the implementation to be cost efficient. As our study is still in the early stages, however, we first want to assess to what extent the autonomous robot and the remote-control robot can provide support to caregivers and visitors in elderly daycare centers. We will then be able to determine in what situations the robot could change from autonomous to remote control modes. We are currently developing an autonomous robot and a remote control robot independently and planning to conduct experiments with these robots.

Design implications for autonomous robot

As we have discussed above, the robot should be able to display availability to multiple visitors simultaneously and display recipiency to individual visitors in establishing a connection for service. The robot can display availability in part by rotating its head. A simple mechanical turn of the head, however, may not be sufficient. We believe that the robot should move its gaze from one person to another similar to the way human caregivers did in our observation. We have developed a robot that can make eye contact with humans (Kuno et al. 2005; Miyauchi et al. 2004, 2005), and while we can basically use this eye contact method, the observations indicate that humans use a range of verbal and non-verbal means to display recipiency such as nodding, approaching the visitor, and/or saying 'What happened?'

Figure 10. Service robot.

We are developing a robot that has the capabilities mentioned above (Fig. 10), using ROBOVIE-R ver.2 (ATR) as a system platform. Although the human vision system works fast enough to detect a person looking towards us, and the human field of view is wide and can often notice a person looking at us even though he/she is far away, computer vision does not work as fast and efficiently. Even if the robot uses an ultra wide lens with the same field of view as a human, it is difficult to obtain enough resolution to detect people in images. To help alleviate this, we attach three cameras on the robot's chest. Regardless of the head direction, the robot continues observing the scene with these three cameras. Although several faces can be detected at the same time, the robot moves its head from one detected face to another to display availability. If the robot detects a face that is looking at it, the robot turns its body in the direction of the face, then examines if the face is still looking at it with the camera (eye) on its head. The robot then makes eye contact, approaches the person, and says, 'What happened?' In the above process, if the face direction is not apart from the robot's front and the robot does not need to turn its body, the robot proceeds to the eye contact process without saying anything.

Design implications for a remote control robot

An important result of employing robots in elderly care is that robots enable a remote human caregiver to display availability to multiple visitors simultaneously. This display of availability can be done crucially through a robot's movements (e.g. circulating around the room while turning its head). Several of the current authors have presented the results elsewhere (Kuzuoka et al. 2004). This robot has three camera units on its body so that its horizontal field of view is about 180 degrees in total. On the remote control caregiver's side, the image of the camera unit is displayed on three horizontal screens (Fig. 11). Since the robot's head motion and a remote controller's head motion are synchronized, the remote controller's natural head motion when he or she scans the three-display units is reflected in the robot's head motion. Recently, we have added a display on the robot's chest to display a remote controller's face and named it GESTUREMAN-3.5 (Fig. 12). When this robot is used for elderly day care, we expect that visitors will be able to recognize a remote caregiver's availability both through the robot's head movement and the remote caregiver's face displayed on the robot's chest.

Figure 11. Remote operator's environment

Figure 12. Robot with chest display

As was shown in Data 4, a visitor may reach out and touch a caregiver’s body to attract his or her attention. A robot thus should be able to sense such physical contact so that the remote caregiver can orient his or her head and make eye contact with the visitor.

We are aware of some existing remote control robots that have displays that show a remote participant’s face (for example, Jouppi 2002). We have to clarify, however, how a Mona Lisa effect caused by 2D face images on a display affects eye contact between a remote caregiver and a visitor. Although we need further studies to clarify this, we expect that the combination of a display and a robot’s head orientation can alleviate this problem.

Combination of autonomous and remote control modes

Recently we have started a project to combine the autonomous mode and the remote-control mode. The prototype robotic system is being developed for a museum (Fig. 13). The robot makes eye contact with a visitor, and approaches him or her. Then it faces the visitor and starts explaining the exhibit. If the robot finds that the visitor keeps looking at the robot during the explanation, the robot turns its head towards the visitor and asks, ‘Do you have any questions?’ The autonomous mode then changes to the remote-control mode. A human operator watches the three displays. The head direction of the visitor is sent to the robot to move its head. The robot shows which direction the visitor is paying attention to through its head motion. Such head motion, which is similar to the autonomous mode, facilitates smooth communication between the visitor and the robot. We are aware that needs and behaviors of visitors are very different between the museum and the elderly day care centers. Based on ethnographic studies, we need to modify the robot so that it works effectively in the elderly daycare center.

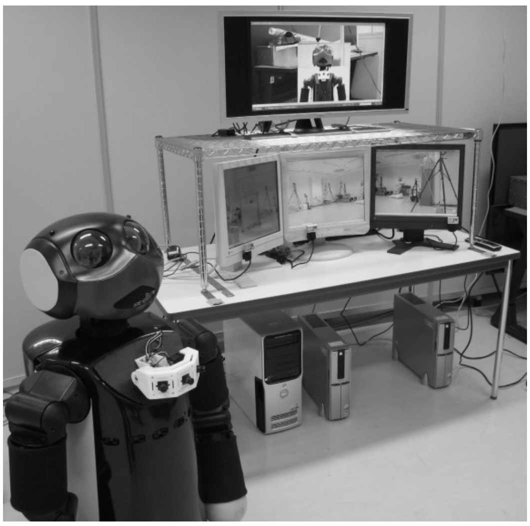

Figure13. Guide robot and remote site.

Conclusion

In this paper, we have analyzed naturally occurring interaction in elderly day care centers in Japan with a focus on prior-to-request and request behaviors, and related the findings to implications for developing robots for use in elderly day care centers. Though we did not fully cover issues such as the details of request behavior (Zaliyana et al. 2004), we have attempted to understand what is going on in those centers, and use those understandings to develop robotic systems by focusing on 1) how prior-to-request and request behaviors are initiated between visitors and caregivers, and 2) how prior-to-request and request behaviors are coordinated between them.

In situations in which multiple parties are co-present while engaging in multiple tasks, a caregiver has to deal with a range of issues. How is it that a caregiver establishes a connection with other visitors who need assistance and then provides service? Such issues cannot be fully examined under experimental situations in which it has already been established that individuals perform requests to a specific other person. In order to design a robotic system that can function in naturally occurring, multiparty contexts, we have proposed a three-step approach that begins with an examination of human-human interaction. We believe that any attempts to design and implement robots in service care settings should take into account the socio-culturally organized interaction that goes on in those settings. The use of ethnographic approaches is crucial to uncovering the lived details of socio-cultural practices prior to, and alongside, the design phase. Our results are applicable for developing robots that can work collaboratively not only with humans but also with other CSCW systems. That is, as our study deals with problems related to request behaviors among multiple parties, our findings are applicable to system development for other service related areas. Along these lines, we hope that such a robot will be developed not only for elderly care centers but also within a range of other service contexts.

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