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A List of Household Objects for Robotic Retrieval Prioritized by People with ALS

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***Abstract*—Studies have consistently shown that object retrieval would be a valuable task for assistive robots to perform, yet detailed information about the needs of patients with respect to this task has been lacking. In this paper, we present our efforts to better understand the needs of motor impaired patients with amyotrophic lateral sclerosis (ALS) with the goal of informing the design and evaluation of assistive mobile robots.**

We first describe our results from a needs assessment involving 8 patients from the Emory ALS Center. We provided patients and caregivers with cameras and notepads to document when objects were dropped or were otherwise unreachable in daily life. This study confirmed the importance of robotic retrieval and resulted in documented cases of objects being dropped and out of reach for 1 to 120 minutes. Based on this initial study, we created a questionnaire to assess the importance of various objects for robotic retrieval using the Likert scale. We administered this survey to 25 patients through in-person interviews.

These studies culminated in a prioritized list of 43 object classes for robotic retrieval. Using the Friedman test we show that the rankings from the patients are statistically consistent. We present this list and discuss its implications for designing and benchmarking assistive robots.

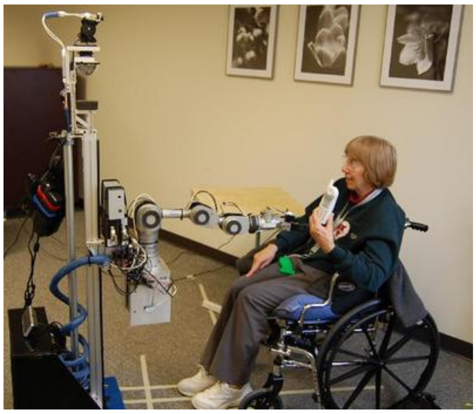

Fig. 1. The autonomous mobile manipulator EL-E (pronounced “Ellie”) delivering a cordless phone to an ALS patient – photo used with patient permission and IRB approval.

I. Introduction

Assistive robots that manipulate everyday objects in the home have the potential to enhance the lives of the motor impaired. In collaboration with the Emory ALS Center, the Healthcare Robotics Lab at Georgia Tech has been developing an autonomous mobile manipulator named EL-E to assist motor-impaired patients with amyotrophic lateral sclerosis (ALS), see Figure 1. ALS is a progressive neuro-degenerative disease that causes a person to gradually lose the ability to move his or her body. As part of this research, we wish to better understand how robots can effectively meet the needs and preferences of people with ALS.

To date, we have focused most of our effort on assistive object retrieval. Studies by other researchers have consistently shown that object retrieval would be a valuable capability for assistive robots [1]. We believe object retrieval could also serve as a foundation upon which to build additional assistive capabilities, since it involves core functionality such as grasping and delivering objects.

Although previous studies have looked at object retrieval, detailed information about the needs of patients with respect to this task has been lacking. Within this paper, we describe two complementary studies we have conducted to help identify which types of objects patients consider to be most important for robotic retrieval. These studies have resulted in a prioritized list of object classes for robotic retrieval that can be used to inform the design and evaluation of assistive robots.

We include this list in the paper. We have also created an accompanying web page that has links to example objects that can be purchased through online vendors. This web page, which we intend to help researchers work with comparable sets of objects, is currently located at http://www.hsi.gatech.edu/hrl/object_list.shtml.

II. Related Work

Robots that traverse unstructured domestic environments and manipulate everyday objects are beginning to become a reality in labs around the world. To date, however, there is a lack of agreed upon benchmarks for evaluating robotic systems for mobile manipulation. Unlike the speech and vision communities [2], [3], [4], [5], robotics researchers have yet to define common design specifications or benchmarks by which they can evaluate the performance of their systems. This deficiency is especially acute in the area of robot manipulation. Existing research generally suffers from one or more of the following drawbacks in evaluation:

- ***Insufficient Number of Objects***: There are many examples where a system is evaluated using a very small set of objects [6], [7]. While this may demonstrate a new capability, it is often difficult to evaluate the generality of the method.

- ***Insufficient Variation in Object Type***: Human environments are full of distinctive objects. Frequently, the objects selected for evaluation represent only a small portion of the natural variation found across objects in domestic settings [8], [9].
- ***Objects Without Justification***: Most researchers have applied a “grab-bag” approach to object selection. Without a clear method by which to select objects for robotic evaluation, researchers can be tempted to cherry-pick objects that are well matched to their robot’s capabilities. The lack of common benchmarks can reduce reproducibility, complicate comparisons, distort perceptions of system performance, and work against negative results. Moreover, it obscures the path for progress by hiding the areas most in need of improvement.

Many researchers in rehabilitation robotics have studied the needs of users. In the 1990s, researchers from the Palo Alto Veterans Affairs Medical Center and Stanford University collaborated to perform assessments of user needs in clinical settings. The researchers utilized focus groups to brainstorm ideas on assistive technologies to help with the activities of daily living (ADL) of people with disabilities [10]. Recently, researchers in the area of human-robot interaction (HRI) have adapted user centered design (UCD) approaches from the human-computer interaction (HCI) community. For example, Adams applied goal-directed task analysis to assess the needs and requirements for human users to operate a large number of robots [11].

Researchers in rehabilitation robotics and orthotics have also conducted a number of surveys to assess the needs of potential users [1], [12], [13]. Many of the surveys focused on determining which *tasks* of daily living should be prioritized for assistive manipulation. These surveys have asked people with motor impairments and the clinical personnel who assist them. Object retrieval was consistently found to be of high priority. For example, Stanger and colleagues [1] examined survey results reported from six different studies related to the development of devices for assistive manipulation, including the MANUS manipulator. The studies reported the results of pre- and post-development surveys identifying high priority tasks with respect to users’ needs and expectations. Simple object fetching and retrieval was among the most frequently-cited tasks with which participants expected to receive help. Other tasks, such as personal hygiene, eating and drinking, and entertainment, also received significant mention. More focused examinations of the needs of the motor impaired employ direct observation through long term ethnographic studies. For example, Forlizzi and colleagues [14] interviewed and observed elderly people to study an ecology of independent living. Meanwhile, Ray and Street [15] studied the experiences of caregivers for people with motor impairments.

Much of the research on robots for assistive mobile manipulation has focused on wheelchair-mounted robot arms controlled via teleoperation, such as the MANUS arm [16], FRIEND-I [9], and others [17]. There has recently been a surge of interest in autonomous mobile manipulation in domestic environments [18], [19], such as EL-E in Figure 1 [7]. At this time, there are no clear standards for the evaluation of manipulation capabilities of assistive robots.

TABLE I
DEMOGRAPHIC INFORMATION OF NEEDS ASSESSMENT PARTICIPANTS

Gender	Male (6), Female (2)
Ethnicity	White (6), African American (2)
Age	39 - 62 (mean 53.5) years
Diagnosis	16.73 months ago (average)
Caregivers	spouses (5) family (2) paid personnel (1)

III. INITIAL NEEDS ASSESSMENT

To verify the applicability of the object retrieval task for our user population (ALS patients), we conducted a preliminary user needs assessment. This needs assessment confirmed that object fetching is a useful task in its own right, and provided details and insights upon which we based the survey.

A. Needs Assessment Methods

We recruited eight participants for the needs assessment study through the Emory ALS Clinic. During the course of regular medical examinations and consultations, nurses of the clinic gauged interest of candidates who were prescreened with a preference toward participants capable of verbally communicating and living near the clinic (and by extension, our lab). After patient consent and an introduction from the nurses, we introduced the study to the patient and the caregiver (if present), read the consent form to them, obtained their signatures, and then recorded their demographic information. The participants’ demographics are listed in Table I. Although the group was of modest size, the composition was diverse and representative in ethnicity, gender, and age. In addition, the patients’ disease progression and associated physical limitations varied.

To perform indirect observation of personal experiences of object retrieval, we asked participants and caregivers to photograph instances where objects were dropped or were otherwise unreachable over a period of about a week. As shown in Figure 2, we provided a Kodak C613 digital camera attached to a pen and memo pad to record these events. The memo pad was designed to summarize events of manipulation difficulty, and included the following sample entry:

Object:	Standard-sized single-volume spiral notebook, blue
Location:	Living Room
Orientation:	Fell flat on floor about one foot between both the edge of the sofa and myself.
Method of Retrieval:	Brother picked it up
Time Elapsed: (until retrieved)	30 minutes

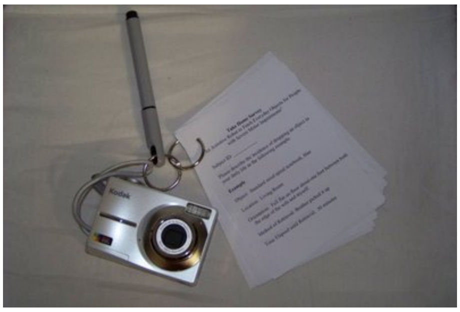

Fig. 2. Digital camera with take home survey

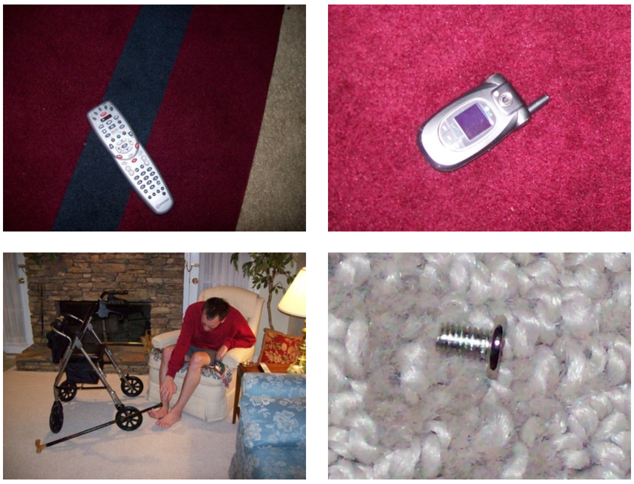

Fig. 3. Photographs of dropped objects that posed manipulation challenges, taken by ALS patients in their homes. Clockwise from top left: TV Remote, Cellular Telephone, Small Hobby Screw, Walking Cane. Photos used with patient permission and IRB approval.

After this period of indirect observation via participant self-documentation, a researcher visited participants' homes to perform a final, follow-up interview aided by the photographs and memo entries. In some cases, participants did not take photographs, either by choice or due to physical limitations. The visiting researcher asked follow-up questions to better understand the situational context of documented entries. The interview questions covered object identity, object location, participant mobility, object recovery, and object delivery methods. In this paper, we present results from this assessment that are especially relevant to object retrieval. Assuming participant consent, the visiting researcher also took photographs of the participant's home environment.

B. Needs Assessment Results

In total, 36 instances of object manipulation difficulty were recorded (by six of eight participants) by photo and/or memo, either by the participant or the caregiver. One participant was unable to record incidences because he did not have a caregiver to help him when he experienced the difficulty, and another did not experience much object manipulation difficulty because his motor impairments were very minor. The pictures not only represented dropped or unreachable objects, but also general problems related with object manipulation. Therefore, pictures and recordings of ancillary tasks, such as opening food containers and brushing hair, were also collected. The remainder of this discussion focuses on the results related specifically to object retrieval.

Figure 3 shows a few pictures of dropped objects taken by the participants in their own homes that posed manipulation challenges. As anticipated, participants commonly dropped everyday objects on the floor, such as TV remotes and cellular / cordless phones, and then faced the challenge of retrieval. However, some less-anticipated objects, such as the walking cane, were encountered. Curiously, the participant who took the photo of the cane in Figure 3 did not use the cane for walking, but rather to assist with grabbing objects from the floor (using a combination of his foot and his cane). Very small objects were also recorded, such as medicine pills, and the small hobby-screw shown in Figure 3.

During the photographing session, we asked participants to record the time elapsed until an object was retrieved, either by themselves or with help from caregivers. The collected time gives a sense of the latency of object retrieval. Six participants recorded more than one case of latency, with 22 cases in total. In one case, a participant waited two hours for a caregiver to arrive and retrieve the desired object. In another, the participant repetitively and vigorously tried to retrieve an object by himself, taking approximately 30 minutes to succeed. The remaining 20 cases took less than five minutes each, some less than 1 minute. The cases with shorter waiting time occurred when a participant had less severe motor impairments or when a participant could get immediate assistance from an accompanying caregiver.

While this study explicitly focuses on the *object* variability, it is important to understand that there are a number of other environmental variations that will contribute to the success or failure of a robotic manipulator in households. For example, Figure 4 contains photos taken at participants' homes that illustrate some of the challenges that will be faced by in-home robots: uneven lighting, specular reflection, varied textures, various floorings, and clutter. Clearly, homes present significant challenges to mobility and object detection. It is also worth noting that many ALS patient homes were either modified for or purchased for (wheelchair) accessibility. For example, many were ranch-style homes or contained custom ramps, as shown in the figures. Although these characteristics may not apply to the broader motor-impaired population, it does suggest that robots with wheeled mobile bases, i.e. those without the ability to traverse stairs, can be useful to the ALS population.

Final interview questions were structured into categories of objects, mobility, retrieval method, laser pointer, acceptable performance, and other questions. In this paper, we focus on the results of object related questions on which we based the following object questionnaire. As summarized in Table II, the participants frequently dropped objects and tried not to use breakable or heavy objects for fear of dropping them.

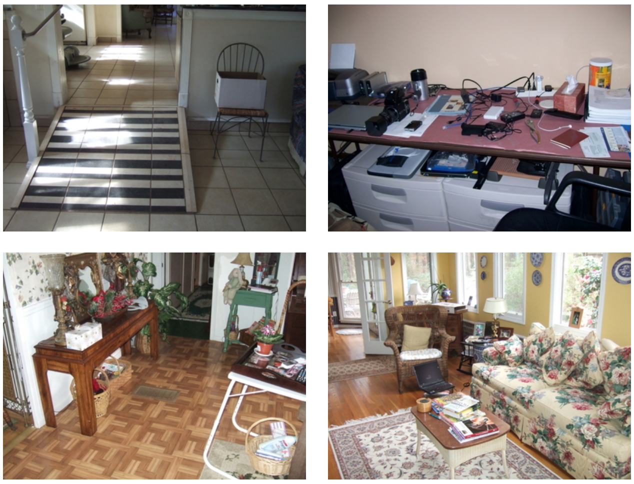

Fig. 4. Photographs showing challenges associated with household environments. Photos were taken in ALS patients' homes. Photos used with patient permission and IRB approval.

TABLE II
OBJECT-RELATED QUESTIONS AND ANSWERS

Questions	Summary of Answers
Frequency of dropping	5.5 times per day(average)
Frequently dropped items	Phone/cellphone (4) Magazines or newspaper (3) TV remote (3) Pills, fork, pens (2) each
Most important to retrieve	Phone or cellphone (2) Walking cane (2) Key, pencil, fork(1 each)
Avoided objects	Breakable things (glasses, dishes) (4) Heavy things (laptop) (2)
Difficult tasks	Dressing (buttoning, putting on socks) (2) Personal hygiene (2) Carrying, transporting (2)

The most common objects were phones and paper materials. Phones and walking canes were rated highly with respect to retrieval importance. Participants experienced difficulty or were no longer able to perform tasks such as dressing, bathing, and carrying heavy objects.

Of most pertinence to this paper, the preliminary needs assessment experiences allowed us to create an initial set of object classes of importance to our user population. We created the initial list by first including objects that were emphasized by patients in their logs and interviews. We then augmented this list based on our experiences interacting with the patients in the clinic and through visits to their homes, in order to create a broad list of 43 objects. While creating this list of objects, we used the following categories to inform our decisions:

- ***Medical***: Medical objects include medication bottles and boxes, as well as pills; unfortunately, this is a critical category for users with motor impairments, whether due to ALS or aging. These objects were one of the most referenced in the preliminary needs assessment, hence they have been placed in a category all their own.
- ***Dining Room***: Most of the objects in the dining category relate to eating, such as kitchen utensils, food/drink containers, etc.
- ***Bathroom***: Bathroom objects are distinct from others in that they focus almost exclusively on personal hygiene.
- ***Personal Belongings***: This category constitutes items that remain in near proximity when staying at home
- ***Living Room***: Anecdotally, we found that motor-impaired individuals spend a dominant portion of time in the living room. Living rooms are dominated by large objects such as sofas, couches, tables, and televisions, which are not manipulated directly, but rather have objects of interest placed atop or beside.
- ***Bedroom****: Most of the dropped items of consideration in bedrooms relate to clothing.

We did not initially include clothes (from the bedroom), but added them later at the behest of participants. Table III shows the object list.

TABLE III
INITIAL LIST OF OBJECTS

Category	Objects	
Medical	Prescription Bottle Medicine Box	Pill
Dining	Non-Disposable Bottle Cup / Mug Plate Can Spoon Knife	Disposable Bottle Plastic Container Bowl Straw Fork
Bathroom	Toothpaste Hairbrush Hand Towel	Toothbrush Soap
Personal Belongings	Purse Coins Keys Wristwatch Credit Card Pen / Pencil Walking Cane	Wallet Bills Cellphone Lighter Glasses Scissors
Living Room	Cordless Phone Book Newspaper Small Pillow	TV Remote Magazine Mail
Bed Room*	Shirt Socks	Shoe / Sandal Pants

IV. PRIORITIZED LIST OF HOUSEHOLD OBJECTS

Using the list derived from the preliminary needs assessment, we sought to determine a ranking for the objects, capturing their importance for retrieval as determined by our user population. Through our needs assessment we found that obtaining accurate statistics on the patients' difficulties would be challenging and possibly misleading. By directly asking patients about their object retrieval priorities, we could not only address frequency of use and difficulty of retrieval, but also other factors, such as object importance and personal preference. For this reason, experts at the ALS Clinic at

TABLE IV
DEMOGRAPHIC INFORMATION FOR INTERVIEW PARTICIPANTS

Gender	Male (15), Female (10)
Ethnicity	White (15), African American (10)
Age	37 - 81 (mean 58.6) years
Diagnosis Duration	3 - 120 (mean 30.3) months

Emory University suggested that results be obtained via in person interviews with ALS patients rather than mailed or web surveys, to ensure that the results would be of high quality. It is also worth emphasizing that even though the questionnaire used images of specific objects, list represents *classes* of objects rather than specific instances (i.e. the object class of all shoes, rather than a particular brand, style, color of shoe).

A. Interview Methods

In total, 25 ALS patients (demographics in Table IV) participated interviews which lasted less than 30 minutes. We recruited 17 Patients while they visited the Emory ALS Clinic. A nurse at the clinic first asked the participants if they have interest in the research. If a patient showed interest, the interviewers entered the room and briefly introduced the goals and existing functionality of EL-E in assistive object manipulation. The remaining 8 participants' interviews occurred during their visits to the Healthcare Robotics Lab, where they worked with EL-E as part of another user study.

The interview began by reading consent forms to the participants and receiving their signatures. When the participant had difficulty in writing, a caregiver signed on behalf of the participant and a demographic survey followed.

In accordance with IRB approval, a questionnaire was given that asked participants to indicate the relative importance of each object in a list (with the representative pictures in Table V) based on a 7-point Likert scale [20]. The questionnaire follows:

> For a research project at Georgia Tech and Emory, we are developing a robot to help people to manipulate everyday objects. We are trying to find a list of common objects to be useful in robot manipulation research for us and other robot researchers. Your help from experience would be essential in creating a validated list.
> Following is a list of objects with pictures which might be important to be retrieved by a robot if they are dropped or unreachable in your daily lives. For each object in the list, please give a number from 1 to 7 by following criteria for the importance of retrieval based on your experiences.

7	Very Important
6	Important
5	Slightly Important
4	Neutral
3	Slightly Unimportant
2	Unimportant
1	Very Unimportant

The interviewer read these instructions to the participant and explained how to rate the relative importance of object retrieval. Then the interviewer showed the images of objects printed on the documents and requested the participant's rating on the 7 point Likert scale shown above. The participant would either verbally indicate the rating, or point to it if speech was too difficult.

An open-ended follow-up question concluded the interview.

> In your experience, if you have objects which were not included in the above list but you think are necessary to be retrieved by a robot, please list them.

The 10 interviews were followed by a preliminary results analysis. We discovered that half of the participants indicated articles of clothing such as socks, pants, and shirts as additional objects. The initial list omitted clothing based on experiences from the needs assessments since ALS patients were expected to have great difficulty dressing, even if clothes were retrieved by a caregiver (or robot). At the behest of participants, the clothing items were added to the list for the remaining 15 interviews.

V. RESULTS: THE PRIORITIZED LIST OF OBJECTS

By averaging the Likert-scale rating of each object across all participants we derived a numerical ranking of the objects. Based on the responses of ALS patients, we can consider highly ranked objects to be more relevant (and broadly applicable) to robotically assisted object retrieval compared to lower ranked objects. The results of this ranking (with the averaged Likert score) is shown in Table V. We selected a typical example from each object class in order to assign an approximate mass and longest length to the class for analysis; these are recorded in the table as "weight" and "max size." For each object class, at least one person gave a score of 7, and for all but 6 of the object classes (spoon 4, fork 4, disposable bottle 2, hand towel 2, TV remote 5, and book 2) at least one person gave a score of 1. So although there is general agreement on the list, individual preference still plays a significant role in the priority a specific object will receive. The prioritized list represents what objects are most agreed upon to be important.

Among the 43 total objects, 40 objects were rated by all 25 participants. Three additional objects (socks, shirt, and pants) were added based on consensus about "additional objects" from the first 10 participants. While some participants thought the list was comprehensive, others suggested additional objects through the open-ended follow-up question, though there was no consensus on further omissions. Some of the other objects mentioned were glass cups, milk jugs, coffee pots, tissues, and bath towels. Two patients also mentioned "*myself*" as an

TABLE V
PRIORITIZED LIST OF OBJECT CLASSES

Rank	Object Class	Image	Rating Mean	Rating Stdev.	Weight (grams)	Max size (cm)	Rank	Object Class	Image	Rating Mean	Rating Stdev.	Weight (grams)	Max size (cm)
1	TV Remote		6.64	0.57	90	18	22	Credit Card		4.96	2.37	5	8.5
2	Medicine Pill		6.36	1.55	1	2.2	24	Medicine Box		4.88	1.88	25	10
3	Cordless Phone		6.28	1.31	117	15	24	Bill		4.88	2.26	1	13.5
4	Prescription Bottle		6.08	1.31	25	7	26	Straw		4.80	2.22	1	20
4	Fork		6.08	1.12	39	18	26	Magazine		4.80	2.02	206	27.5
6	Glasses		6.00	1.53	23	14	28	Plastic container		4.72	2.16	49	13
7	Toothbrush		5.96	1.81	15	19	29	Newspaper		4.60	2.16	247	31
8	Spoon		5.92	1.19	38	17	29	Non-disposable bottle		4.60	2.00	709	20
9	Cell Phone		5.88	1.69	76	9	31	Pants		4.53	2.47	539	100
10	Toothpaste		5.72	1.84	160	20	31	Shirt		4.53	2.47	229	66
10	Book		5.72	1.46	532	24	33	Wallet		4.48	2.33	116	100
10	Hand Towel		5.72	1.46	65	58	34	Small Pillow		4.44	2.08	240	38
13	Mail		5.60	1.98	22	24	35	Socks		4.40	2.08	41	23
14	Cup / Mug		5.56	1.76	267	12	36	Hairbrush		4.36	2.46	100	24
15	Soap		5.44	2.08	116	9.5	37	Can		4.32	2.08	350	6.4
16	Disposable bottle		5.40	1.66	500	13	38	Coin		4.16	2.51	6	2.5
17	Shoe		5.36	1.98	372	30	39	Walking Cane		3.76	2.47	1140	94
17	Dish Bowl		5.36	1.66	154	13	40	Wrist Watch		3.52	2.35	86	10
19	Keys		5.28	2.28	24	8.5	41	Scissors		3.40	2.33	25	14
20	Dish Plate		5.24	1.85	182	18	42	Purse / Handbag		2.84	2.29	380	24
21	Pen / Pencil		5.04	2.13	3	14	43	Lighter		2.04	1.99	91	6
22	Table Knife		4.96	1.95	76	24							

TABLE VI
SUMMARY BY OBJECT GROUP

Group	Score	Count	Average Weight (grams)	Average Max Size (cm)
Very important	6 – 7	6	51.2	11.2
Important	5 – 6	15	133.4	19.0
Slightly Important	4 – 5	17	281.7	43.0
Not Important	1 – 4	5	196.5	15.2

additional object, which represents the desire of some patients to have a robot capable of repositioning their bodies. Robots that can grasp and change the position of body parts (legs and arms) or the whole body would be extremely useful for this patient group. Although important, we are treating this as a separate category of manipulation that is distinct from object retrieval, as represented by the prioritized list of objects.

To test the statistical consistency of ratings by participants, we performed the Friedman test using SPSS statistics software. The Friedman test can statistically answer this type of questions with the classic example being : "n wine judges rate k different wines. Are the ratings consistent?" More succinctly, the Friedman test is designed to determine if a factor has a significant effect on variation of a dependent variable regardless of uncontrollable variables [21]. A parametric statistical test of ANOVA (analysis of variance) would not be well-suited to analyze the data we collected, as we used the ordinal values of the Likert scale, which violates ANOVA's assumption of normality. This technique has been utilized by other robotic researchers to evaluate robotic systems [22]. The Friedman test assumes the experiment is in a complete block design and our data has missing values for 3 additional objects which has 15 participants data. Thereore we conducted two separate Friedman test for 1) 43 objects from 15 participants, and 2) 40 objects from 25 participants. Since the data have ties in different objects, the Friedman test does not produce exact p-value but gives approximated value of asymptotic significance, by which we can interpret the results in the same way. The first test resulted in an asymptotic significance of 0.00 with 42 degrees of freedom and a chi-square value of 192.632. The second test resulted in an asymptotic significance of 0.00 with 39 degrees of freedom and a chi-square value of 239.935. The results quantitatively demonstrate that the rankings provided by the patients were consistent.

Finally, we have divided the objects list into 4 groups based on the scores as in Table VI. One interesting observation is that the group of highest scores are generally smaller and lighter. Specifically, a medicine pill, which is the smallest object, is in this group.

VI. DISCUSSION

The resulting list of objects provides a guide to robot design since the set of objects has implications for specifications such as payload capacity. We found that the objects with higher rankings are generally smaller and lighter compared to objects with lower rankings. This observation could potentially help researchers when designing a robotic system. For example, prioritizing the manipulation of small, light objects compared to larger, heavier objects would cover many of the highly ranked objects.

It also suggests methods for benchmarking the object fetching capabilities of a robot, since a robot could be empirically evaluated using representative objects from the top N object categories from the prioritized list. For example, there are 21 objects with an average ranking of "Important" to "Very Important" (i.e., in the range [6,7]) for assistive robotic retrieval. A common benchmark using a validated set of objects can prevent cherry-picking in evaluation. Researchers of assistive mobile manipulation can use the presented list as a method of benchmarking their implementation by testing their robots to manipulate the list of object presented in this paper which were validated to be important by a group of ALS patients. For researchers beyond assistive applications, the method of creating and validating the list of objects in this study can be a foundation on which they can create lists of objects tailored for benchmarking their own applications.

The method of ranking in the study has several limitations. First of all, Some objects are gender-specific, such as wallets and purses. Although some male participants said that they use purses because they are bigger and not easy to drop, generally wallets are more important to male participants and purses are to female participants. Because we had more male participants than female, the results should be interpreted carefully. However, there are more male ALS patients compared to female and the gender structure of participants group is largely in line with the population structure. Therefore, addition of gender specific objects were inevitable.

In psychological experiments, researchers utilize randomization to counter order effects. In the user interviews, we did not randomize the order of objects because we did not expect any fatigue effects from short interview times of typically 5 minutes. In fact, we did not find any significant effects of ordering in the importance ratings. For example, the top-ranked object of TV remote was 34th and the second ranked medicine pill was the third object in the questionnaire. However, more accurate measurement of participants perceptions would be attainable by carefull study design.

VII. CONCLUSION

We have proposed a ranked list of 43 everyday objects for the evaluation of assistive manipulation systems operating in domestic settings. By developing benchmarks tailored to specific application domains and user populations, robotics researchers have the opportunity to ground their research and answer the otherwise subjective question: *What is functionality is important?*. We also believe benchmarks of this nature can enable researchers without direct access to user populations to contribute to progress in a validated way.

VIII. ACKNOWLEDGMENTS

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