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LONG PAPER

Involving domain experts in assistive technology research

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Abstract Teams engaging in assistive technology research should include expertise in the domain of disability itself, in addition to other areas of expertise that are more typical in human–computer interaction (HCI) research, such as computer science and psychology. However, unexpected problems can arise when HCI researchers do not adequately plan the involvement of domain experts in a research project. Although many research teams have included domain experts when designing assistive technologies, there has been little work published on how to best involve these experts in the research process. This paper is a first step towards filling that void. Based on the authors' own experiences involving domain experts in research, as well as those documented in the literature, five types of domain experts and three broad roles that domain experts can play are identified, and five guidelines for their involvement are presented. This analysis will be useful to anyone in the assistive technology and universal accessibility communities, especially those who are in the early stages of conducting research in this area. It is intended to lay the foundation of best practices for involving domain experts in assistive technology research.

Keywords Methodology · Assistive technology · Domain experts · Disabilities · Participatory design

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1 Introduction

Human–computer interaction (HCI) is an inherently multi-disciplinary field of research. It is common, for example, to include computer scientists, psychologists, sociologists, and designers in a research project, to name just a few. It is widely accepted that no single discipline provides sufficient expertise and breadth of perspective for any given project involving the design of interactive technology. Nowhere, is the need for such multi-disciplinarity more evident than in the design of assistive computer technology. There are substantial challenges involved in designing technology for *users with disabilities*. Some of these challenges, such as familiarizing the whole research team with the domain of the impairment, are universal in assistive technology research. Other challenges, such as communicating with a user who has a language impairment, are specific to particular target populations.

The involvement of domain experts can help to mitigate those challenges. The required expertise can take on many different forms, ranging from a clinician's educated understanding of the disability to a spouse who has specific, personal knowledge of a target user's abilities and disabilities. Target users can also be considered one type of domain expert, as they often have considerable expertise in the impairment themselves, and should always be included in the research where possible. However, target users may not always be capable of or comfortable communicating their expertise to others. In these cases, domain experts

other than target users can be involved as intermediaries, providing increased access to users through their existing relationships and established trust with both the community and specific individuals. The focus of this paper is on domain experts other than the target users themselves.

Although domain experts can greatly help HCI researchers in assistive technology research, the authors' experiences have revealed that unexpected problems can sometimes arise from this collaboration. For example, there can be a mismatch in expectations of research outcomes between the domain experts and the researchers. Further examples are presented later in this paper. Such problems can increase the time and effort required to complete the project, negatively affect the relationships with domain experts, or negatively impact the research outcomes.

Established guidelines or recommendations on how to best involve domain experts in assistive technology research would be useful in mitigating these problems, but none, to the authors' knowledge, have been published. Although many research teams have documented how they have involved domain experts (e.g., [3, 4, 8, 22]), we have found little reflection published on the challenges in working with domain experts and how to best involve these experts in the research process. Furthermore, there has been little work published identifying the various types of domain experts that can be included or the roles they can play. This paper is a first step towards filling that void. It was decided to include only material that is drawn from both the authors' experiences as academic researchers working with domain experts, as well as chosen accounts published in related research literature. The paper does not address the types of domain experts who work on assistive technology in industry or for governments. The analysis presented is intended to be useful to anyone working on assistive technology or universal accessibility solutions, especially those who are in the early stages of research and development, such as graduate students.

The paper begins by highlighting two of the authors' projects, on which the remainder of the paper draws heavily, and describing other related research projects that involve domain experts. Next, how to work effectively with domain experts is discussed, first by identifying the different types of domain experts, followed by the roles that they can play in an assistive technology and universal accessibility research project. Then five guidelines for working with domain experts are presented, and the paper concludes with some thoughts on how to extend the current analysis.

1.1 ALEX project

The ALEX (*A*dult *L*iteracy support application for *EX*periential learning) project [11–13] aims to design an assistive handheld application for adults with limited literacy skills. *Adults with limited literacy skills* are defined in this project as "individuals, aged 18 and over, whose current literacy skills in their native language limit their ability to understand, use, find, produce, and benefit from printed information required in daily activities at home, at work and in the community" [11]. The project had three initial objectives: (1) identify ways that handheld computers could assist adults with limited literacy skills; (2) identify appropriate and effective design processes given the needs of the target population; and (3) design a handheld application to assist this population. The researchers used a three-phased approach (focus groups, participatory design, and evaluation) that involved target users and domain experts in order to produce an ecologically valid design for an assistive application (described in detail in [13]).

Literacy facilitators and tutors were involved as domain experts in this research because of their experience with adult literacy students and with adult literacy resources. These facilitators and tutors support their students by individually assessing their abilities, locating suitable learning resources, and helping them work through learning activities. The literacy facilitators are employed by a literacy organization to support a *group* of students. By contrast, the tutors are volunteers assigned to help an *individual* student. In the first phase of the project, three literacy facilitators and six literacy students participated in the focus groups. In the second phase, one literacy facilitator and four literacy students were involved in the participatory design of the prototype. In the third phase, one literacy facilitator and three tutors helped in recruiting a number of their literacy students to participate in the evaluation, and were available during the evaluation in case any problems arose.

1.2 PhotoTalk project

The PhotoTalk project aims to design an assistive handheld application for people with aphasia that will allow them to easily take photographs and share them with others, thereby supporting communication [1]. Aphasia is an acquired language impairment that can affect speaking, comprehension of spoken language, reading, and/or writing [16]. Although people with aphasia often have difficulty communicating with written or verbal language, they generally retain their ability to recognize images [20]. Aphasia is most often caused by a stroke, although it may also result from a brain tumour or injury [19]. The incidence of stroke increases with age, so the majority of people with aphasia are older; however, aphasia can affect people of any age. The PhotoTalk research is being

conducted within the Aphasia Project, which is a multi-disciplinary research project with the objective of designing technology to support people with aphasia in their daily lives [2].

Speech-language pathologists (SLPs) were included in this research because of their clinical expertise on aphasia; they provide language therapy to people with aphasia on a daily basis. In the first phase, two SLPs were involved in the participatory design of PhotoTalk. In the next phase, an informal usability study was run with five aphasic adults; a third SLP helped recruit participants for that usability study. In the final phase, a university researcher with an SLP background (the fourth author) helped to design a longitudinal field study, which was run with three participants. She also conducted language assessments with those aphasic participants.

1.3 Participatory design

In the past, HCI assistive technology research projects have usually involved domain experts to some degree (e.g., [5, 9, 17, 21]). However, publications arising from these projects generally have not discussed the specifics of how these experts were involved in the projects, such as the roles they played in the research. However, a recent trend where HCI researchers are beginning to document reflections on collaborating with domain experts can be observed (e.g., [3, 4, 8, 14]). Many of these collaborations, including those in the ALEX and PhotoTalk projects, have involved participatory design.

Participatory design (PD) is a mainstream HCI design method that has seen some success in assistive technology research, which is often due in part to the involvement of domain experts. PD is generally recognized as an effective approach for designing technology for most populations because target users and other stakeholders are involved as equal participants (i.e., team members) in the process, which ensures that the target users' needs are considered from the outset. However, carrying out PD effectively is challenging, even with non-impaired participants. This is because it can be difficult for target users and system designers to effectively communicate their ideas given their diverse backgrounds and perspectives [10]. This challenge can be exacerbated when working with users with impairments.

Domain experts have often been recruited to help reduce challenges in PD, such as those related to communication, that arise due to the disabilities of the target users. PD traditionally relies on strong written and oral communication between the design team members, but these abilities cannot always be assumed with special needs populations, rendering the design method extremely difficult or impossible to accomplish. Thus, many HCI researchers have involved domain experts in PD to facilitate communication with users with impairments. For example, as part of the Aphasia Project, a university researcher (the fourth author) with a background in SLP facilitated communication between HCI researchers and one target user to design a file system, the File Facility, for people with aphasia [6]; in another study, she helped four aphasic individuals to communicate with the rest of the PD team to develop the ESI Planner, a daily planner that is enhanced with sound and images for people with aphasia [15].

Domain experts have also been involved to help modify the PD process so that users with disabilities can participate. For example, Wu et al. [22] also employed a multi-disciplinary team to develop a portable system, OrientingTool that helps people with anterograde amnesia orientate themselves when they are not sure where they are. Their PD team consisted of six people with anterograde amnesia, one HCI researcher and one neuropsychologist who specializes in the assessment and treatment of severe memory disorders. Wu et al. recognized that the typical PD process needed to be adapted for their population due to their participants' amnesia. Specific changes were made to help the participants throughout the process by directly supporting their memory during and in between design sessions. One technique involved reviewing important meeting items frequently, such as before and after each meeting, and before making key decisions during the meeting [24]. Wu et al. [24] used their experiences to create a framework that researchers can use to adapt PD methods to make them more appropriate for a population with cognitive disabilities.

Although PD often involves collaborating with target users, this is not always possible when they have disabilities, and it is often necessary to include other people in the design process. For example, Cohene et al. [4] used a PD approach to develop a multi-media life story system for a woman with Alzheimer's Disease. Since the target user was only able to participate at a minimal level, her family members were included in the design process. Many researchers have labelled a domain expert in this type of representative role as a *proxy* [3, 4, 8]. Although this role is often valuable, some concerns emerge about the use of the term *proxy*, which are discussed later in this paper.

2 Types and roles of domain experts

2.1 Types of domain experts

Although domain experts are often individuals with formal education or clinical training on a particular disability, there are other domain experts who should not be

overlooked. In this section five types of domain experts are identified that can be involved in a research project, in addition to the actual target users themselves. The target users should also be involved in the design process wherever possible.

1. A *university researcher* is an expert in one or more domain areas related to the target users' disabilities. Their knowledge and experience helps in planning and carrying out the research.
2. A *clinician* is a trained professional who supports target users by providing objective assessments and appropriate intervention. Clinicians work extensively with many users in the target population and have been trained to help these individuals improve their condition. Examples of clinicians include medical doctors and SLPs.
3. A *formal caregiver* is employed to assist the target user with individual daily needs, and therefore has detailed information about the daily life and the functional abilities of the target user. An example of a formal caregiver is a nurse in a hospital or care facility.
4. A *facilitator* is someone who may not have specific training in relation to the needs of the target users, but who organizes groups or facilitates other types of interactions with target users. Although facilitators are not clinically trained, their experiences and regular contact with target users provide them with insights that can be very valuable to a research project. Examples include stroke club facilitators and the literacy facilitators in the ALEX Project.
5. A *spouse* or *other close family member* of a target user can be a key domain expert to involve in a research project. The family member is aware of the specific strengths and weaknesses, interests, personality, motivation, sources of confusion, and energy levels of a particular target user and can help facilitate communication between the researchers and the user.

The authors have personal experience as HCI researchers working with four of the above types of domain experts. In the ALEX project, literacy *facilitators* and tutors (also considered *facilitators*) were involved. In the PhotoTalk project, the research team included two *clinicians*, as well as a *university researcher* who was also a *clinician*. The PhotoTalk project also involved stroke club *facilitators*, a *spouse* and a *close family member*. Although *formal caregivers* were not involved in these two projects, other projects have reported their involvement in the literature (e.g., [4]). This list is not exhaustive, and there may be other types of domain experts that have been involved in HCI research projects. In particular, a limitation of this list is that it does not address the types of domain experts who work on assistive technology in industry or for governments. This is an area for future research.

It is important to recognize the variety of motivations that different types of domain experts may have for participating in assistive technology and universal accessibility research. For example, *university researchers* may be motivated to participate in order to discover interesting research results that can be published and to advance knowledge in a particular research area. *Clinicians*, *formal caregivers*, and *facilitators* may be motivated to participate because they can help develop new and effective assistive technologies and treatments for the population that they support. Furthermore, a *spouse* or *family member* of a target user may be motivated to participate in order to help improve the quality of life for his or her loved one. The research team should be aware of the expectations arising from these motivations as they may conflict. Potential conflicting motivations are described below.

2.2 Roles of domain experts

Although an individual can typically be only one type of domain expert, that person can carry out one of many roles in a research project. This section describes roles that domain experts have played both in the projects discussed in this paper and in other research projects reported in the literature. The roles that domain experts can play are illustrated in Fig. 1, and fit into three broad categories: *researcher*, *liaison*, and *representative*. Each of these is discussed in turn.

2.2.1 Researcher

As the name suggests, domain experts in the *researcher* role are involved as members of the research team. They can both inform the design of the research and assist in executing the research. They do not have to be a *university researcher*—other types of domain experts can also help in planning and carrying out the research.

Domain experts can inform the research design by providing input on how to adapt HCI methods to fit the target population. For example, the aforementioned OrientingTool project [22] involved a neuropsychologist as a *researcher* on the team who helped to carefully adapt a participatory design approach for people with anterograde amnesia. The close collaboration between HCI researchers and the memory expert from the Baycrest Centre was instrumental in creating a process within which the target users could contribute [23]. Domain experts as *researchers* also can play a key role in ensuring that a study adheres to the ethical treatment of the participants who are disabled; namely, that these people, who are often more vulnerable than the average person, are not exposed to a risk of harm

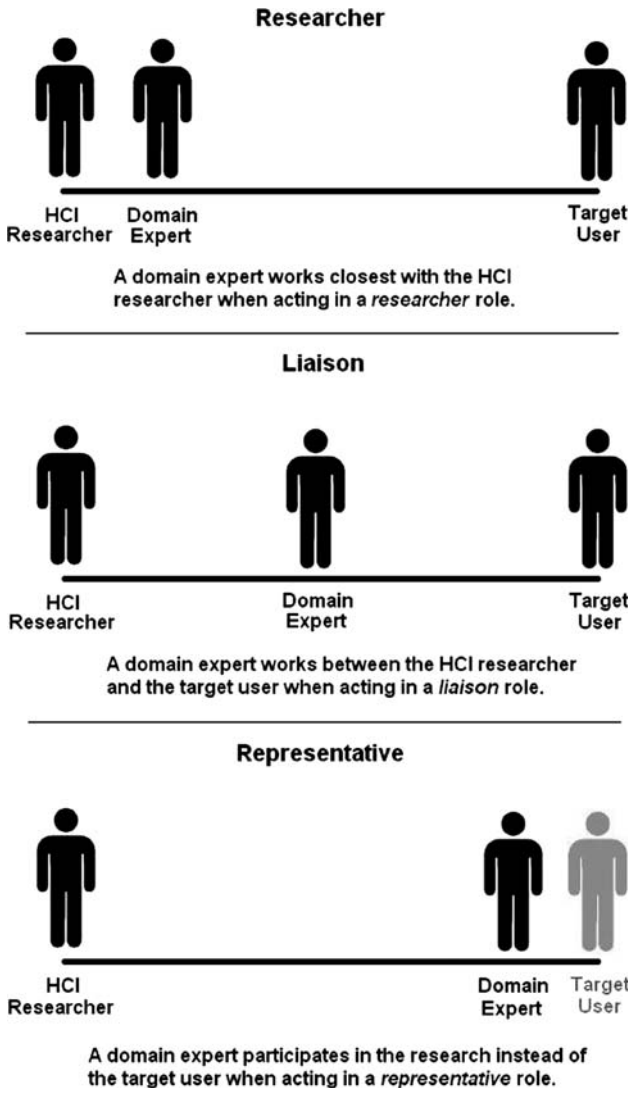

Fig. 1 Various roles that domain experts can play in assistive technology research

beyond what they encounter in their daily lives. The involvement of domain experts as *researchers*, as well as *liaisons* (described below), may reduce any potential risk of harm to participants.

Domain experts often conduct parts of the research. For example, some domain experts have the expertise to suggest and perform functional assessments or standardized testing. People with disabilities can have widely varying abilities, which can make obtaining meaningful results challenging. This challenge is exacerbated by the fact that the sample size of these research studies is often small. Standardized and detailed information about each participant's abilities can help the research team learn to interpret the results. For example, one of the researchers of the Aphasia Project is also a certified SLP, and she administers, scores, and interprets standardized tests for the Aphasia Project team. The results of these tests have been very valuable for analyzing data and providing meaningful results [15, 18].

The extent of the domain experts' involvement in the research team will depend on their background and experience. *University researchers* in the disability field may be able to greatly contribute to the planning of the research because they understand the mechanics of research, whereas *spouses* may only be able to provide feedback on aspects of a study design that will be problematic for their loved ones.

2.2.2 *Liaison*

Another role domain experts can perform is to act as a *liaison* between the research team and the target users. *Liaisons* can facilitate subject recruitment, act as communication intermediaries, establish trust with the target population, and assist participants in understanding and completing consent forms.

Finding target users with particular disabilities can be a major challenge. The population of these individuals is often relatively small. In addition, the disabilities of the target users often lead to social isolation, which makes it difficult to identify potential participants. Domain experts are often associated with organizations that support these target users and can help the research team connect with and recruit potential participants.

As communication intermediaries, domain experts can facilitate communication between the research team and target users, whose disabilities (for example, aphasia) make it difficult for them to communicate. A domain expert acting as a *liaison* may teach the research team strategies for communicating with the target users. At times, the *liaisons* may be present, for example, during a research or participant recruitment session, to directly facilitate communication between the researchers and target users.

Domain experts can also help increase target users' trust for the research project, which is very important in recruiting participants. Given their vulnerabilities, people with disabilities can be reluctant to participate unless they are confident that they will not be put in an uncomfortable or harmful situation. Unlike HCI researchers, domain experts often have existing relationships with one or more target users. When a domain expert known in the community demonstrates trust in a project, the target users are more likely to trust the project. In the PhotoTalk project, the community ties of an SLP, who played the role of *liaison*, facilitated the recruitment of participants for the usability study. The SLP was able to identify appropriate individuals from her group and invite them to participate in the study.

In addition, domain experts can help ensure that the target users provide informed consent before they participate in research by helping them understand and complete consent forms. For example, in the ALEX project, the researchers gave literacy students consent forms to fill out. The consent forms were worded using relatively simple language and contained images to augment the written language. However, the researchers were not sure whether the literacy students would be able to fully understand the form on their own. To address this, the researchers asked each literacy student's facilitator (or in some cases, the student's tutor) to go over the consent form with the student and co-sign the consent form.

2.2.3 *Representative*

Although target users should ideally be involved in all aspects of assistive technology research, their involvement is not always practical or feasible. For example, some of these individuals have physical disabilities that make getting from their home to the place of the study a substantive challenge. As another example, very few target users may be available to participate in a research project and it may be preferable to involve them in the evaluation but not in the design. In these cases, domain experts can take part in the design process as *representatives* of the target users. Domain experts may represent one target user (e.g., their spouse), they may represent many individual target users (e.g., a group they work with), or they may be an expert on a particular area related to the target population as a whole (e.g., how to improve literacy skills). In the ALEX project, four literacy students and one literacy facilitator were recruited to form the participatory design team and represent a range of target users in design decisions. The literacy students who participated had varying levels of literacy skills; each contributed to the design in the role of a potential target user. The literacy facilitator represented other potential users, such as her students, and provided input based on her perception of their needs. The researchers found the input from the different viewpoints to be very useful.

The term *proxy* has often been used in the literature for this *representative* role (e.g., [3, 4, 8]), but this term may be problematic. The definition for proxy is "a person authorized to act for another; an agent or substitute" [7]. Recent discussion at a CHI workshop on Designing Technology for People with Cognitive Impairments suggested that this term is potentially misleading for this role [CHI 2006 Workshop on Designing Technology for People with Cognitive Impairments, personal communication]: it implies that the expert acts as a full substitute for the target user. However, target users, especially those with disabilities, are most familiar with their current work processes and their needs, and can not be fully substituted by anyone else. Domain experts can imagine how a target user would interact with a computer system, but they cannot do so as accurately or as realistically as the target user. The authors suggest that the term *representative* is more appropriate than *proxy*. *Representative* is generally defined as "a person that represents another or others" [7], which is a better fit for the role that domain experts play.

3 Guidelines for working with domain experts

This section presents five guidelines for involving domain experts in assistive technology research. The guidelines were selected based on experience working with domain experts and reports by others in similar situations documented in the research literature. Focus was narrowed to five guidelines that are believed to have helped most in the conducted research, as well as ones that could have prevented undesired results if they had been followed a priori. Although these guidelines follow common sense, they were not all immediately apparent at the outset of the conducted projects. Just as the authors would have benefited from having them at the outset of their research, these guidelines are likely to benefit others in the research community.

These guidelines are inter-related and are not meant to be followed sequentially; it is recommended to give them consideration at each phase of a research project.

3.1 Anticipate the necessary domain expert roles and match the available experts to the roles

The roles that domain experts can fulfill to cover the necessary expertise and skills must be determined during the planning stage. The research team should determine whether domain experts are needed as additional *researchers* to help them better understand the target users' needs and requirements, and the associated research and development issues. The team should also find out whether they need domain experts as *liaisons* to, for example, help communicate with target users or build trust with an established community. Further, the team should decide whether they need domain experts as *representatives* to act as target users when it is not possible or practical to involve target users at particular points in the research process. These types of considerations are important for anticipating the domain expert roles that should be involved in a project.

After determining the domain expert roles, the research team should match the available domain experts to the required roles based on their abilities, personalities, and interests. In the ALEX project, three literacy facilitators

were involved in the focus groups as *representatives*, but only one literacy facilitator was needed to act as a *representative* for the participatory design phase that followed. After getting to know the literacy facilitators during the focus groups, Leung et al. [11–13] were able to invite the most suitable literacy facilitator to participate in the participatory design phase. This assignment was based on the literacy facilitator's abilities and personality.

Understanding the skills and abilities of available domain experts is necessary for determining how the domain experts can contribute to the project. In the PhotoTalk project, the researchers worked with two SLPs who were acting as *representatives* during the design phase of the prototype. One of the SLPs had previous experience designing technology and the other did not. Having these two experts act as representative users worked well because it brought two very different perspectives to the research. The SLP with experience designing technology was more aware of the technical possibilities and was often able to give concrete suggestions on how to implement her ideas. The other SLP was less aware of the technological constraints, which allowed her to think more freely about a range of design possibilities. This example shows that domain experts, even if they bear the same professional title, can have varying backgrounds and bring different skills to the research process. It is important to match potential experts to roles based on their full skill set.

Conversely, not understanding the limits to available domain experts' abilities can negatively impact the project. Boyd-Graber et al. [3] involved SLPs as *representatives* in their project. They noted that the SLPs they worked with had difficulty analyzing paper prototypes because they could not envision the problems target users would have when interacting with the system. Boyd-Graber et al. suggested that providing the SLPs with training on usability evaluation techniques may have helped them better evaluate the paper prototypes. This demonstrates that research teams must continuously evaluate the abilities of the domain experts to assess whether they are a good match for the roles that they are being asked to play.

3.2 Recognize the lack of expertise in a particular domain related to the design or target user

Even once domain experts have been recruited to work on or with the research team, gaps in necessary expertise and abilities can remain. In relation to Guideline #1, it is crucial to recognize any of these potential gaps in advance. Although there may be many potential roles, it may not always be possible to find a suitable expert for each role. Appropriate experts may not be available, or characteristics of available domain experts may make them unsuitable for certain roles. If possible, this lack of expertise should be compensated for. Even if these gaps can not be addressed, it is essential to recognize the risks that occur due to lack of expertise.

For example, Cohene et al. [4] involved family members as *representatives* in the design process for their multi-media life story of the target user. Unfortunately, the available family members were at least 20 years younger than the target user. This large age gap created the risk that the first 20 years of the target user's life would not adequately be covered in the multi-media life story. As Cohene et al. stated "it is not the risks that impede design, but the failure to recognize such risks". Because they identified this risk early in the research project, they were able to compensate by making an extra effort to gather stories from the first 20 years of the target user's life from another source and ensure that these years were adequately documented in the life story.

As another example, no one on the ALEX project team was able to administer standardized language literacy tests. The researchers realized this lack of expertise early in their project and planned a self-assessment of reading and writing levels in their evaluation. In other words, the subjects assessed their own literacy without the involvement of domain experts. Although the data analysis in the ALEX project may have been stronger if it had been possible to correlate the results from the system evaluation with the participants' actual literacy skills, the researchers were able to compensate by using the self-assessment scores. There may not always be an adequate way of compensating for the missing skill set, but even if this is the case, it is crucial to recognize the missing skills at the beginning, so that it is clear how it will impact research.

3.3 Anticipate and mitigate possible interference between roles when a domain expert plays multiple roles

Although having a single domain expert play multiple roles in a project can be an efficient and beneficial way to incorporate their expertise, carrying out one role may interfere with carrying out another. It may not be possible to anticipate all of the potential interference, but it is advantageous to consider and address potential problems that may arise.

For example, in the PhotoTalk project, the two SLPs who participated in the design phase as *representatives* were also asked to act as *liaisons* by helping to recruit participants for the evaluation phase, which involved a field study. It was discovered that the SLPs had an unstated expectation that the prototype would be fully developed by the evaluation phase, which became problematic during

recruiting. Once the SLPs realized that PhotoTalk was a research prototype, not a finished application that the clients would be able to keep and use permanently, they felt uncomfortable recommending that their clients participate in the study. These mismatched expectations arose in part because the SLPs participated in the design phase, and were very keen about the envisioned design and quite optimistic about its potential impact. The research team should have been more aware of the potential for increased optimism from the SLPs due to their participation in the design of the tool. This problem could have been mitigated before it arose through very clear communication at each stage of the project about the expected outcomes (see Guideline #5 for more about communication).

3.4 Consider domain experts' interest in research, perspectives, and expectations

The perspectives, expectations, and level of interest of the domain experts should be taken into consideration throughout the research project. It is easy for researchers to plan and implement a project entirely from their own points of view. However, it can be problematic if the motivations and expectations of some domain experts are not in harmony with the project goals. Understanding each domain expert's perspective will help the team to proactively minimize any negative effects that may occur.

For example, *family members* may be particularly sensitive when discussing the needs of loved ones. In Cohene et al.'s [4] project family members of individuals suffering from Alzheimer's Disease were involved in research as *representatives*. Cohene et al. found that they needed to consider the needs of the family members as they became more involved in the participatory design stage of the research. The experts participated in reminiscing activities about their family member's life, which was emotionally difficult at times because the person with Alzheimer's Disease did not always remember important events or people from her life. Cohene et al. recognized in advance the potential difficulty reminiscing could cause, and referred the family members to social workers for support.

There can also be a disparity in the perspectives between the domain experts and the researchers; sometimes domain experts may not realize what information is important for the research project. Boyd-Graber et al. [3] noted that much of the relevant information they learned from the SLPs who were acting as *representatives* was not revealed in their formal, semi-structured interviews. The researchers later overheard the SLPs having a casual conversation in which they were discussing pertinent information, which had not been communicated in the formal interviews between the researchers and the SLPs. The information had not been shared by the SLPs during those interviews because it was tacit, that is, embedded in the context of their work. Once the researchers realized that their interviews had not exposed all of the relevant information they were able to employ a different interviewing technique, which revealed further information from the SLPs and changed the direction of the research.

Compensating domain experts appropriately also requires understanding their motivation for participating in the research project. In the PhotoTalk project, the research team thoroughly discussed the expectations the SLPs might have for compensation before beginning recruiting SLPs. Their exact motivations for participating in the research were not evident. It is important to think about what motivates domain experts to get involved in a project, and how their motivation will affect how they contribute to the project. Domain experts may expect to be compensated for their time based on an hourly rate or the rendering of a particular deliverable. They may also be happy to volunteer their time because of their belief in the good of the project. In part, this may be a cultural difference and is also likely dependent on the time commitment required. An open conversation about the goals of the research project with the domain experts can help to identify the experts' motivations.

3.5 Clearly communicate roles and research goals to involved domain experts

The more clearly the research team understands the domain experts' perspectives (Guideline #4), the easier it is to effectively communicate the experts' roles and the research goals to them. Extremely clear and explicit communication between the researchers and domain experts will help ensure that everyone participating in the research understands their expected involvement.

The need for clear communication can be exemplified by comparing the approaches taken to involve domain experts in the ALEX project and in the PhotoTalk project. In the ALEX project, the literacy facilitators were officially considered participants in the focus group and participatory design phases. Therefore, the documented description of their involvement and mandatory consent forms had to be passed through the university ethics board. This forced the researchers to carefully think through how the literacy facilitators would be involved in the project and document it clearly on consent forms. In the ALEX project, no major misunderstandings between the researchers and the domain experts arose, which is likely due to this explicit approach.

In the PhotoTalk project, the SLPs were considered part of the research team. Their involvement was only informally documented, which did not need to be passed through the university ethics board, and the SLPs did not need to fill out

consent forms. In this project, problems arose because of misunderstandings between the researchers and the SLPs (as described earlier in the example for Guideline #3). These problems may have been avoided if the researchers had followed the approach taken in the ALEX project.

It is also important that the researchers ensure that the domain experts who are recruited as *liaisons* communicate clearly with potential target users. If the domain experts clearly understand the goals and requirements of the project, it is more likely that they will be able to convey the correct information to target users when they are recruiting for participation or discussing the research project. If possible, it is useful for a researcher to be present when the communication is taking place. Although this may be more time consuming for the researcher, being present makes it easier to correct any inaccurate statements made by the domain expert. In the ESI Planner project [14, 15] for example, Moffatt et al. found that an SLP who was acting as their *liaison* was unintentionally misrepresenting the system when she was recruiting participants. She was describing the system to potential participants as rehabilitative, even though the HCI researchers felt they had clearly explained to her that it was not intended as a rehabilitative tool. Because of this miscommunication, the participants' expectations created awkward situations for the researchers when the participants realized that ESI Planner was not rehabilitative. As noted by Moffatt, it is important to confirm with each participant that the purpose of the research is understood [14].

Formally documenting the procedures, as required by ethics review boards, is likely to be a valuable way to ensure that the expected involvement of domain experts is clearly communicated to them. One possible approach is to design different research consent forms for each role type and phase in the research process. In this way, when the research requires a shift in the domain experts' role (for example, from researcher to liaison) a new consent form could be administered to the domain expert. This would make the shift in roles explicit to everyone and would specifically ensure that the shift does not go unnoticed to the domain expert. This approach would increase the clarity of communication between researchers and domain experts and provide a natural opportunity for domain experts to dialog with the researchers about their evolving roles and whether they desired to remain involved in the project. This approach would also help remind domain experts of the overall research project goals.

4 Conclusions

This paper is a first step towards comprehensively documenting the involvement of domain experts, other than target users, in assistive technology research. It is very important to consider the various types of domain experts that might be suitable for a particular assistive technology or universal accessibility project. Five types of domain experts were identified: *university researcher*, *clinician*, *formal caregiver, facilitator*, and *spouse* or other *close family member*. Three broad categories for the roles that a domain expert can play were also described: *researcher*, *liaison* and *representative*. It was found that a single domain expert can play one or more roles in a research project. Five guidelines were then presented on how to best involve domain experts in assistive technology research:

1. Anticipate the necessary domain expert roles and match the available experts to the roles
2. Recognize the lack of expertise in a particular domain related to the design or target user
3. Anticipate and mitigate possible interference between roles when a domain expert plays multiple roles
4. Consider the domain expert's interest in research, perspectives and expectations
5. Clearly communicate roles and research goals to involved domain experts.

The reported analysis is intended to lay the foundation of best practices for involving domain experts in assistive technology research.

Considerable work remains to be done to better understand how to involve domain experts in assistive technology and universal accessibility research. As reported in this paper, it is not uncommon to use domain experts as *representatives* when it is difficult to involve target users in certain research phases. There are still many open questions about how to do this most effectively. How should traditional research methods, such as PD, be modified when involving domain experts as *representatives*? Should domain experts, for example, be given some training to help them assume the role of the target users, such as role-playing? Hybrid approaches were also reported where domain experts are used as *representatives* in addition to the target users themselves. Sometimes they are used together at the same point in the design cycle (for example, target users and *representatives* in a PD session) and other times at different points in the cycle (for example, *representatives* in a PD session, and target users in subsequent usability testing). It would be helpful to identify *when* is best to involve domain experts as *representatives* in the design cycle. Finally, do the answers to these questions depend on the particular impairment under investigation, and if so, how do the guidelines presented need to be adapted to account for different disabilities?

It is the authors' hope that these questions and other issues related to the involvement of domain experts will spark discussion within the community. The authors plan to

continuously revise the guidelines as research projects with domain experts evolve. It would be helpful if other researchers, in academic settings as well as in other settings such as industry or government, would also continuously reflect on their experiences and revise, clarify, and build upon the groundwork presented here.

Involving domain experts in assistive technology research for users with disabilities is crucial, and their involvement is consistent with the multi-disciplinary nature of HCI research. Domain experts have much to contribute, and if their involvement is well planned, their contribution can be maximized. HCI researchers are encouraged to thoroughly consider how to best involve available domain experts in the research and to communicate it clearly to them.

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