Trade-offs in the Design of Multimodal Interaction for Older Adults

Gianluca Schiavo, Michela Ferron, Ornella Mich and Nadia Mana

FBK - Fondazione Bruno Kessler, Trento, Italy
{gschiavo, ferron, mich, mana}@fbk.eu

Abstract. This position paper presents key aspects and trade-offs that designers, ICT and HCD practitioners might encounter when designing multimodal interaction for a specific target group: older adults. The paper draws together literature on multimodal interaction and assistive technology and presents a set of specific findings for older users. Building on these findings, we describe a number of challenges that should be taken into account when designing multimodal technology for this target group. Further reflections highlight the design trade-offs that such considerations might bring, presenting an overview of the design choices and their potential effects.

Keywords: Multimodality, older adults, design trade-offs.

1 Introduction

Multimodal interfaces seek to combine multiple sensory input and output channels in similar ways as in natural interaction. This similarity has led to the expectation that multimodality in human-computer interaction can provide a more natural, robust and flexible form of interaction with respect to more traditional input modalities such as mouse and keyboard. [1, 2]. In this respect, multimodal human–computer interaction has sought to provide not only more powerful and compelling interactive experiences, but also more accessible interfaces to technological devices. Moreover, following the principle of "design for all" and "inclusive design", multimodal technology has been proposed as a possible solution that allows users to use the modality matching their preferences and/or needs, thus making the interaction more flexible [3]. However, despite these potential advantages of multimodal interfaces, the literature reports significant disadvantages. For example, different modalities may interfere with each other and a synchronization problem might arise.

Additionally, combining and coordinating more than one modality might also require more effort for the users [4, 5] and a higher cognitive load [4]. Current research provides findings supporting both assumptions reporting advantages [1, 2] as well as disadvantages [4, 5]. This position paper has the goal to further advance the discussion on this topic by presenting design trade-offs in multimodal technology when designing technology for older adults, a large and heterogeneous user population.

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2 Multimodal Interaction for Older Users

Multimodal interfaces have been considered to improve accessibility for a number of users and usage contexts [3], including the diverse needs of older users [6, 7]. Multimodal systems can integrate a wider range of modalities (such as speech, writing, gaze, touch or mid-air gestures) and better accommodate users' preferences with respect to unimodal interfaces. Furthermore, multimodal interfaces can be more user-friendly for people who have little or no experience with common computer devices, since they offer the possibility to use multiple interaction channels without relying on a single source of input [3]. However, other studies point out that multimodality must be carefully introduced since it might require more cognitive effort to coordinate different input modalities (especially when more than two modalities are involved) and additional physical demand [4]. This may become particularly relevant when considering the cognitive and physical characteristics of older users [8].

Numerous examples of multimodal technology for older adults can be found in the research and on the market. For instance, social robots or telepresence technology are two representative examples of multimodal systems believed to support older users [7]. Before listing the design trade-offs that these or similar interaction modalities might bring in the technology, we summarize a list of design considerations.

3 Design Challenges and Recommendations

Different recommendations for the design of multimodal interfaces for older adults have been discussed in the literature (see for example, [4, 7, 9]) and are summarized below.

Diverse abilities. Multimodal systems provide users with the choice of using the most efficient interaction modality among those proposed by the system. Moreover, users can switch to another interaction modality after a recognition error has occurred in the previous one [2]. However, this requires that the user knows which is the best modality for her/him, or at least "intuitively" uses the best set of multimodal inputs.

Personalization. One-solution-fits-all models are inadequate as they do not consider individual characteristics. The interaction and the interface should be made adaptable and personalized to user preferences and device characteristics. Users should be able to customize the multimodal channels they want to use for a given task in an application.

Interaction patterns. There are large individual differences in users' multimodal interaction patterns [10]: some individuals tend to integrate different modalities in a simultaneous manner and overlap them temporally (simultaneous integrators), whereas others tend to finish one mode before beginning the second (sequential integrators). Older adults demonstrate either a simultaneous or sequential dominant integration pattern [10, 11], however designers should be aware of such differences and multimodal interfaces should accommodate individual interaction patterns.

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Independence. Multimodal interfaces should empower older users to independently interact with the technology, even when there is a specific impairment (for example hearing loss or reduced sight). Multimodal interfaces can also contribute to seniors' perceived independence [7], if they can empower the user to function independently.

Technology reliability. Users should be able to rely on the multimodal technology, especially in the case of assistive technology. For this reason, multimodal processing should be accurate and robust. However, since recognition algorithms are mainly trained on data from non-older population, this might pose limitations on the performance (e.g., due to vocal features characteristics of older adults for speech recognition [12], or slower gesture speed for gesture recognition).

Privacy and context of use. Context of use should be carefully considered when designing multimodal technology [13, 14]: older people have privacy and social acceptability concerns about using some modalities in public spaces (as in the case of speech commands or mid-air gestures [14]). However, one of the advantages of multimodal interaction is the possibility of using one modality rather than the other according to the specific context (e.g., gestures instead of speech commands in noisy environments).

4 Design Trade-offs

When considering the recommendations mentioned above, practitioners and designers might experience a number of design trade-offs, which are situations that involve losing one quality or aspect of the design in return for gaining another quality or aspect. Table 1 presents a summary of design challenges and design trade-offs.

Complexity vs Simplicity. Providing the user with the possibility to interact with more than one modality might increase the interaction complexity. For example, it has been showed that the oldest of older adults (80+) found some modalities or combination of modalities too complex to use when using a multimodal tablet-based application [13]. This trade-off might also affect the system usability: a technology that supports many different modalities might increase in complexity and thus be less usable.

Personalization vs Customization. Multimodal interaction can be tailored to the specific preferences or needs of the user. This process might end up in an over-personalization of the interaction, making it difficult to the user to discover or experiment with alternative interaction modalities. There is indeed a trade-off between personalization, where the system personalizes the interaction to the user, and customization, where the user is in control of the customization process. The latter allows the users to control the interaction, assuming that they know how and what feature to control. The former gives control to the system without requiring an effort from the user, but it heavily relies on system reliability and performance.

Independency vs Assistance. The cognitive effort required to older users for the personalization and customization of system interaction may be avoided by allowing

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other users to take care of the process. For instance, a multimodal technology could be designed to be personalized by caregivers or therapists even though the final user is an

Table 1. Table captions should be placed above the tables.

Design challenges	Interaction context	Multimodal design recommendation	Design Trade-off
Diverse abilities	Need to use the most suitable modality	Give the user or caregiver the choice on the interaction modality or combination of modalities	• *Independency vs Assistance*
Personalization	Need to leverage user's strongest or preferred modality	Dynamically adapted multimodal interfaces	• *Automation vs Control* • *Personalization vs Customization*
Interaction pattern	Need to support user's interaction pattern	Consider individual differences in multimodal interaction patterns	• *Complexity vs Simplicity* • *Automation vs Control* • *Personalization vs Customization*
Independence	Support user's need for self-reliance and independence	User-initiated interaction with multimodal inputs	• *Complexity vs Simplicity* • *Independency vs Assistance*
Technology reliability	Users need to be able to rely on their assistive technologies for critical support	Employ well-developed components and rely on complementary modalities to reduce error rates and to increase usability	• *Automation vs Control* • *Complexity vs Simplicity* • *Independency vs Assistance*
Privacy and context of use	Multimodality requires specific privacy and contextual requirements	Personalization of input/output modalities to better suit the context of use	• *Automation vs Control*

older adult (assistance). However, delegating actions to these users might further increase the caregiver load and could be perceived as an additional demand or burden. This might also decrease older adults independent use of the technology.

Automation vs Control. Multimodal sensors can be used as background controls, to which the interface automatically adapts without any intentional and direct user engagement. In this sense, a proactive system might come forward with suggestions, or

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automatic responses, based on the sensed context and without engaging the user (automation). On the other hand, a reactive system requires the user to initiate action (control), which implies direct attention and control on the activity.

5 Conclusions

This position paper has briefly presented some of the challenges and trade-offs that designers, ICT and HCD practitioners might encounter when designing multimodal interfaces. Even though the analysis focuses on older adults as target user group, most of these challenges hold also for the wider user population.

On one side, this paper presents a reflection on how to identify the design trade-offs for multimodal interaction for older adults. On the other side, further discussion is needed to provide practitioners with methods and processes for dealing with such trade-offs. In this direction, participatory design, co-design and value-centered design approaches [15] can help designers to balance different (and sometime competing) design choices. We think that further discussion on this topic can emerge from the discussion during the workshop.

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