Intuitive interaction framework in user-product interaction for people living with dementia

Chapter 10
Intuitive Interaction Framework in User-Product Interaction for People Living with Dementia

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This chapter is focused on intuitive interaction with various interfaces for people living with dementia. First, we describe the enhanced intuitive interaction framework, which contains a continuum suggesting various pathways to intuitive use that can be included in the design of interfaces. We discuss how it relates to users, and specifically how it may assist users living with dementia. Then three empirical studies conducted over two continents are discussed. Each involved participants living with dementia using interfaces in a lab. Data were analyzed for task completion, reaction times and completion times (Studies 1 and 2), and presence and effectiveness of physical and perceived affordances (two of the proposed pathways to intuitive use on the EFII continuum). These data were then compared according to the enhanced intuitive interaction framework, and the findings suggested that employing interface features that are more familiar and more ubiquitous for the target population would likely make the interfaces more intuitive for people living with dementia to use. The

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implications of these finders for users living with dementia and those designing for them are discussed.

10.1 Introduction

Intuitive interaction research has become firmly established in design and HCI over the past 20 years. As Blackler et al. (2010a, b) noted, intuitive interaction is defined as fast, somewhat non-conscious, and generally accurate interaction with an interface that is informed by past experience or technology familiarity. However, although several studies in intuitive interaction have been focused on designing for older people (e.g. Blackler et al. 2012; Gudur et al. 2013; Hurtienne et al. 2015a, b; Lawry et al. 2011; O'Brien 2019; O'Brien et al. 2011), only a very small amount of work has looked at its potential to help people living with dementia (e.g. Desai et al. 2019), much of it focused on the concept of affordances only (Chen and Liu 2018; Chen et al. 2018). This chapter will use the enhanced framework for intuitive interaction (EFII) (Blackler et al. 2019) to explore results from various empirical studies performed around the world with people living with dementia. Classifying interface features used in the studies according to the EFII framework allows us to understand how accessible they might be to people living with dementia.

10.2 The Enhanced Framework for Intuitive Interaction (EFII)

Blackler et al. (2019) proposed an enhanced framework for intuitive interaction to describe how to make product interfaces both engaging and intuitive. The framework illustrates the parallels and connections between the different dimensions of intuitive interaction. Figure 10.1 illustrates the part of the enhanced framework which indicates the pathways to intuitive use; this is a continuum based on a previous continuum developed by Blackler (2008a) and Blackler and Popovic (2016), which forms the heart of the EFII.

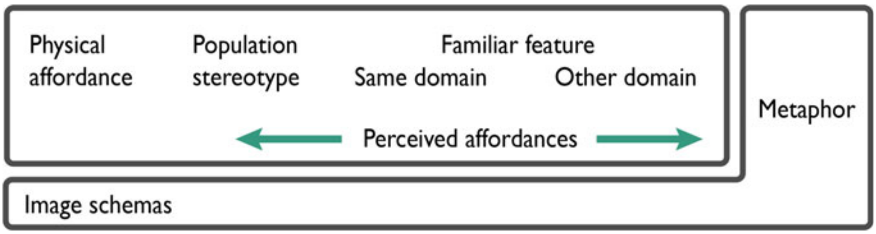


Fig. 10.1 Continuum of pathways to intuitive interaction (derived from Blackler and Popovic 2016)

The continuum of pathways to intuitive interaction is based on sources of previous knowledge or technology familiarity (TF) that users can access. The most ubiquitous types of pathways (on the left-hand side in Fig. 10.1) are learned in childhood, used throughout the lifespan, and broadly applied in many areas of life. Ubiquity of previous experience and therefore potential for more people to be able to intuitively use a feature is highest at the lower end of the continuum and theoretically decreases from left to right. As explained in Blackler et al. (2019), this assumption is based on the fact that these pathways are based on sensorimotor and cultural knowledge held by many people. Pathways at the other end (right-hand side in Fig. 10.1) rely more on complex and specialist knowledge, particular interface experience, or tool expertise held by individuals. People living with dementia may benefit from interface features that are based on the most ubiquitous and longest understood pathways.

Blackler et al. (2019) claim that ubiquity (or near ubiquity) can be achieved by applying the appropriate interface features which relate to the lower (left hand) end of the pathways of intuitive use continuum, to ensure that features are known to everyone or almost everyone in a target population. Features based on physical affordances, image schemas, and population stereotypes will therefore be more intuitive to use for more people. These are the things that are so familiar that they become transparent until they break down or are designed away from their origins and break the mold; that is, these are re-designed so much that they no longer fit the stereotype or possess the affordance (Fischer 2019).

For example, physical affordances (e.g. a door knob that can be grasped and turned by hand) represent those possibilities for action that an environment offers in terms of its properties, mediums, and compositions (Gibson 1979). Physical affordances thus represent prompts derived from physical and material properties of elements in the environment. Perceived affordances are learned conventions (Norman 2013) derived from prior experience with similar interfaces (Blackler et al. 2010a, b). The concept of the perceived affordance refers to users' learned knowledge and culture, and so is equated with population stereotypes or familiar features in Fig. 10.1. Population stereotypes are interactions and icons endemic to a whole society or group.

Image schemas are metaphorical extensions of cognitive concepts which are based on experiences of interaction with the physical world. For example, the up-down image schema is established by experience of verticality, and is applied to our understanding of a range of other concepts like quantity (Blackler et al. 2019). Image schemas can be applied to interface design, and because they are based on past experience, and so well-known and so universal that they become unconscious, image schemas can be defined as intuitive (Hurtienne 2009). Hurtienne et al. (2015a, b) showed that image schemas (which are metaphors) can be ubiquitous (or known to most people in a society), and hence intuitive and inclusive, belonging to the left side of the framework with higher ubiquity rather than on the right with more traditional metaphors.

However, it should be recognized that it is not possible to stay purely at the left-hand side of the diagram (Fig. 10.1). Interface types that are more physical mostly rely on physical affordances (such as grasping, holding and sliding physical objects). Interfaces can, however, also leverage population stereotypes (or cultural conventions), interface features learned when using similar and dissimilar products, and metaphors (turning a wheel, how to use a racket to play tennis, balancing blocks one above the other to create a stack). In this framework (Blackler et al. 2019, Fig. 10.1), metaphor has been detached from the other parts of Blackler's (2008b) original continuum because it became clear that metaphor is not always a simple continuation from the other concepts and in fact could be applied in other ways than originally assumed. The extension of the metaphor block beneath the continuum is intended to demonstrate that metaphor can in fact be applied through any of the other pathways to intuitive use (e.g. physical affordances, familiar features, etc.), and that image schemas, despite being metaphors, are very ubiquitous.

10.3 Intuitive Interfaces for Users with Dementia

We have theorized that the pathways on the left-hand side of the continuum should be more ubiquitous (and hence more accessible to more people in the general population), and that potentially these pathways offer a way for users with dementia to more easily use designed features as these should be things so familiar to them that they are retained in memory after other things may be lost. The work on the reminiscence bump (Astell 2009; Hallberg et al. 2009; Sarne-Fleischmann et al. 2009; Wang 2009) offers some evidence that this may be the case.

Ubiquity is important in the application of intuitive interaction as there are many interfaces that are intended to be used by almost anyone, for example, ticket vending machines, point of sale systems, ATMs, websites of various types such as banking, patient records, government information, as well as operating systems for phones, tablets, and computers. Using many of these interfaces has become less of a choice and more of a necessity in recent years, as everyone is expected to be able to access and manipulate their money and information online and people need to be able to communicate using tools such as email, social media, and text if they are to stay connected with the rest of society. For users with dementia, being able to use these types of tools and interfaces for as long as possible is one of the keys to allowing extended independent living (Astell et al. 2018, 2019; Braley et al. 2018; Gibson et al. 2018; Joddrell and Astell 2019; Kim et al. 2019; Lorenz et al. 2019). This research used interface examples from empirical studies with users living with dementia from two continents to explore whether the design pathways in the EFII can be useful to inform the design of products and interfaces for people living with dementia.

10.4 Studies 1 and 2: People Living with Dementia in Taiwan

The two empirical studies carried out in Taiwan mainly focus on investigations for users with mild dementia interacting with different types of microwave oven interfaces. The definition of mild dementia was based on a score of 0.5 or 1 in the clinical dementia rating (CDR) scale which is often used by neurologists in hospitals in Taiwan. Regarding cognitive skill assessments, participants who scored moderately low in short-term memory function, long-term memory function, and hand–eye coordination were chosen as the participants. In the two studies, the test interfaces involved a custom program that recorded at two different times. First, the time elapsed before a participant touched the screen on the first attempt (i.e. the initial reaction time) was recorded. This can be equated to the latency criterion used to indicate intuitive uses by Blackler et al. (2010a, b). Second, the task completion time was recorded to analyze the overall usability of the test interface. Also, we observed and recorded whether the participants correctly completed tasks and any problems experienced in operating the user interfaces.

10.4.1 Study 1

Seven common types of user interface for setting heating time periods on microwave ovens were collected as the test interfaces, and the corresponding feature types based on the pathways to intuitive use of EFII are shown in Fig. 10.2. To prevent factors such as color and material from influencing the participants, the outlines of the buttons were redrawn using graphics software. During the experiment, testing samples were presented as a white background and black lines and displayed on a tablet computer with a 10-inch touch screen.

A total of 20 participants (mean age = 79.6 years; SD = 10.1) with mild dementia and without major difficulties in verbal communication were invited for the study. The participants were asked to set a specific heating time period and initiate the heating process on the microwave interface. At the beginning of the tests, the participants were required to read the task instructions on a tablet computer. They were orally informed of the task content if they were unable to understand the instructions. After one task was completed, the screen displayed the instructions for the task of the next testing interface, and each testing interface was randomly selected and displayed in a single image.

In Table 10.1, the interfaces with shorter mean reaction times and shorter mean completion times are indicated with *. The one-way ANOVA[1] results show that the average initial reaction times among the seven test interfaces differed significantly ($p < 0.05$). As shown in Table 10.2, the post-hoc ANOVA results showed that B1, C1, D1,

[1]The one-way analysis of variance (ANOVA) is used to determine whether there are any statistically significant differences between the means of three or more independent (unrelated) groups.

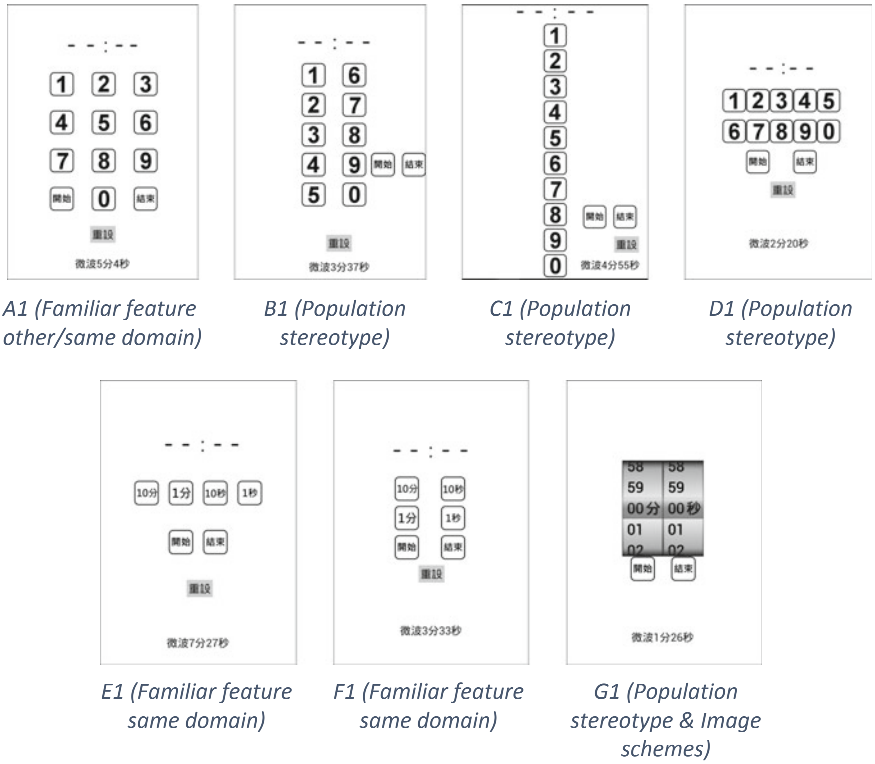


Fig. 10.2 Test interfaces (setting heating time)

and G1 yielded shorter mean reaction times, whereas A1, E1, and F1 demonstrated relatively longer mean reaction times. For completion time, post-hoc ANOVA results showed that average completion times for A1, B1, C1, and D1 are shorter and differ significantly from E1, F1, and G1 (Table 10.3).

The major problems that participants experienced during task operation can be seen in Table 10.4. The results indicated that among the participants who did not complete the tasks, most failed because of entering incorrect numbers or not understanding how to enter heating time periods. The most common method of setting heating time periods on the microwave ovens was to enter time directly. For example, to enter 5 min and 23 s, users needed only to press the numeric keys 5, 2, and 3 sequentially. Several of the participants did not understand this method, which resulted in long periods of operating time and entering incorrect information.

Table 10.1 Results of Study 1

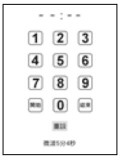
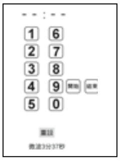
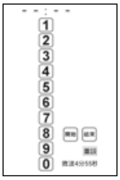
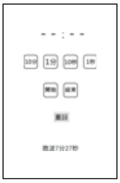
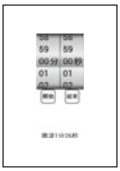
Interface	Feature type	Feature image	Average initial reaction time	Average completion time	Participants who did not correctly complete the task
A1	Familiar feature other/same domain		14.7	28.2*	10 50%
B1	Population stereotype		10.5*	23.9*	5 25%
C1	Population stereotype		5.8*	21.7*	6 30%
D1	Population stereotype		9.5*	25.4*	4 20%
E1	Familiar feature same domain		14.2	57.5	5 25%
F1	Familiar feature same domain		13.1	48.4	9 45%
G1	Population stereotype Image schemes		3.2*	69.3	4 20%

Table 10.2 Post-hoc *p* values for initial reaction times in Study 1

Interface	A1	B1	C1	D1	E1	F1	G1
A1		0.054	0.002	0.091	0.891	0.613	0.000
B1			0.012	0.708	0.099	0.276	0.001
C1				0.120	0.000	0.000	0.064
D1					0.005	0.228	0.011
E1						0.687	0.000
F1							0.000
G1							

Table 10.3 Post-hoc *p* values for completion times in Study 1

Interface	A1	B1	C1	D1	E1	F1	G1
A1		0.136	0.130	0.218	0.001	0.001	0.003
B1			0.519	0.499	0.001	0.000	0.001
C1				0.282	0.001	0.000	0.001
D1					0.000	0.000	0.001
E1						0.236	0.360
F1							0.107
G1							

Table 10.4 Observation records of setting heating time task in Study 1

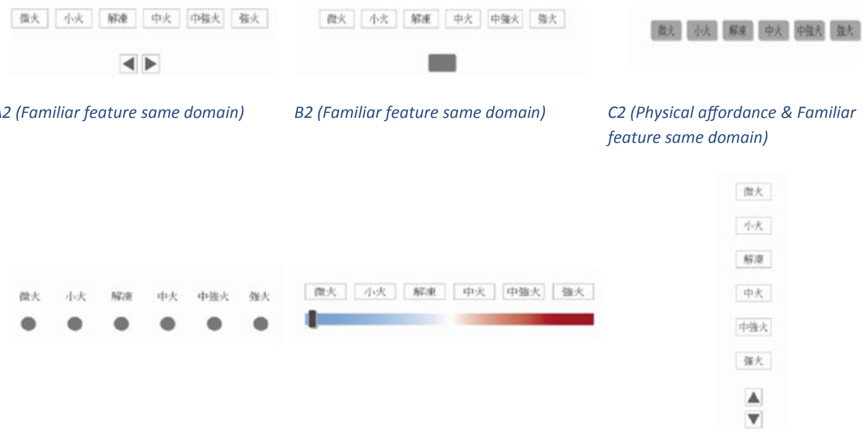
Test interface	Observation Reason
A1	Not understanding how to enter heating time periods Entering incorrect numbers
B1	Entering incorrect numbers
C1	Not understanding how to enter heating time periods Entering incorrect numbers
D1	Not understanding how to enter heating time periods Entering incorrect numbers
E1	Spending relatively longer time on understanding how to enter heating time periods Failure to complete the task (seconds were not set after minutes were set)
F1	Failure to enter correct heating time periods Failure to complete the setting of minutes and seconds
G1	Not understanding how to set heating time periods Not understanding the operating method

10.4.2 Study 2

Six different types of interface for adjusting cooking power were used as the test interfaces, and the features as they correspond to the pathways are shown in Fig. 10.3. As in Study 1, graphics software was used to redraw the interfaces. The participants were asked to adjust the cooking power to medium-high (available levels include slow, low, thawing, middle, medium high, and high). Three of the interfaces (A2, B2, and F2) were operated by pressing buttons at the bottom to cycle through the available power settings. C2 was operated by directly pressing the buttons labeled with the

Table 10.5 Results of Study 2

Interface	Feature type	Feature image	Average initial reaction time	Average completion time	Participants who did not correctly complete the task
A2	Familiar feature same domain		14.2	34.7	1 4%
B2	Familiar feature same domain		13.4	32.2	2 8%
C2	Physical affordance Familiar feature same domain		13.9	18.8*	0 0%
D2	Familiar feature same domain		14.9	22.3*	0 0%
E2	Population stereotype		10.5*	32.7	3 12%
F2	Familiar feature same domain		15.2	34.5	0 0%



A2 (Familiar feature same domain) *B2 (Familiar feature same domain)* *C2 (Physical affordance & Familiar feature same domain)*

D2 (Familiar feature same domain) *E2 (Population stereotype)* *F2 (Familiar feature same domain)*

Fig. 10.3 Test interfaces (adjusting cooking power)

different power settings. D2 was operated by pressing the round buttons directly underneath the power setting labels. E2 was operated by sliding a bar underneath the power setting labels.

The test interfaces were displayed on a tablet computer with a 10-inch touch screen, randomly one at a time. The participants each sat in front of the tablet and read the task instructions displayed on the screen. If they did not understand the written instructions, verbal explanations of the task were provided. No time limit was set for completing the task. Hospital neurologists nominated 25 participants who had mild dementia, demonstrated acceptable communicative and cognitive functions, and were experienced in using home appliances. The participants averaged 81.8 years of age (SD = 7.2).

In Table 10.5, shorter mean reaction times and shorter mean completion times are marked with *. The average initial reaction times for interfaces A2, D2, and F2 were relatively slow, with E2 attaining the shortest average initial reaction time. The post-hoc ANOVA results showed statistically significant differences between mean initial reaction times on E2 and F2, indicating that the slider interface was more likely to be intuitive for the participants in their initial encounters with the interface (Table 10.6). The one-way ANOVA results show that the average completion times among the six test interfaces reach a significant standard ($p < 0.05$). As shown in Table 10.7, C2 and D2 enabled relatively short mean times, which were statistically different from the completion times attained through A2, B2, E2, and F2.

Table 10.8 displays the reasons for participants' mistakes. The primary reason for failing to complete the task was that the participants pressed the incorrect buttons. For example, on B2 and E2, some participants did not realize that the buttons at the bottom of the interface could be manipulated to adjust the cooking power settings.

Table 10.6 Post-hoc *p* values for initial reaction time of study 3

Interface	A2	B2	C2	D2	E2	F2
A2		0.509	0.904	0.747	0.094	0.556
B2			0.808	0.477	0.133	0.177
C2				0.621	0.052	0.524
D2					0.065	0.897
E2						0.028
F2						

Table 10.7 Post-hoc *p* values for completion time of study 3

Interface	A2	B2	C2	D2	E2	F2
A2		0.251	0.001	0.005	0.681	0.962
B2			0.001	0.015	0.917	0.493
C2				0.177	0.000	0.000
D2					0.003	0.001
E2						0.621
F2						

Table 10.8 Observation records of the cooking power task

Test interface	Observation
	Reasons
A2	Did not understand the task and chose the wrong cooking power
B2	Did not understand the task and chose the wrong cooking power Did not understand that the buttons underneath the labels could be pressed to adjust cooking power and chose the wrong cooking power
C2	
D2	
E2	Did not understand that the slider could be moved Inadvertently chose the wrong cooking power
F2	

10.4.3 Discussion

Interfaces with good intuitive interaction for initial operation do not necessarily have equally good usability for users with mild dementia. For example, G1 in Study 2 could effectively guide the subjects' initial operation, but the participants needed more time to complete the task with it. The interface features of the two empirical studies can be classified according to the pathways to intuitive use (Fig. 10.1, Tables 10.3 and 10.5). Some of the interfaces (such as A1, C2, and G1) are hard to simply classify into only one design pathway. For example, the layout of interface A1 might be familiar from users' experiences in using the same product (microwave) or other relevant products (telephone). For initial reaction time, the interfaces with population stereotypes and image schemes present better performance in eliciting users' intuitive initial operations than others. The interfaces with better average completion times are spread between the three pathways: physical affordance, population stereotype, and familiar features. These tended to be toward the left-hand side of the continuum, bearing in mind that there were minimal physical affordances due to the nature of these interfaces. There were no interfaces in Studies 1 or 2 which had significantly shorter reaction time or completion time and are familiar features from other domains (although one was familiar from both other and same domains), and none that were metaphors. This supports our view that interface features that are more ubiquitous could be more intuitive for people living with dementia to use.

10.5 Study 3: Mixed Reality Technologies to Support People Living with Dementia (Canada)

People with dementia struggle to participate in everyday activities such as cooking and laundry as they have difficulty in sequencing tasks in an activity. Technology-based prompting can support people with dementia through the sequences required to complete activities (Mihailidis et al. 2008; Pigot et al. 2003). Mixed reality technologies (MRTs) could offer scalable and adaptable solutions that can be easily deployed. On a continuum of physical–virtual devices, MRTs are anything in between (Desai et al. 2016). Augmented systems can either consist of augmenting the real physical world with virtual objects, as in augmented reality (Azuma et al. 2001) or the virtual world augmented with real physical objects, as in augmented virtuality (Regenbrecht et al. 2004). Prompts can be generated in response to people's actions and behavior (Desai et al. 2019). However, the design and development of MRTs for generating prompts for people with dementia first requires an understanding of how people with dementia interact with MRTs. This study thus investigated interactions and prompts that might be intuitive for people with dementia interacting with MRTs. The aim of this research was to identify factors that contribute to a feeling of being part of the real world with mediated elements, in the context of mixed reality environments. For this to be possible, the interactions with the technology should be natural to the user, such that the cyclic perception action process is invisible to the user. Intuitive interaction in MRTs thus involves non-conscious interactions such that people are unable to explain how and why they made decisions during the interaction, with the presence of mediating virtual technology being transparent to the user, and people experiencing *being there* in the physical real world.

10.5.1 Research Design

Participants were recruited from Alzheimer's Society York Region and Memory and Company, a memory health club in Toronto, Canada, for people living with dementia. An observational study was carried out in participants' homes and at Memory and Company. Nine people with dementia (MoCA = 19–24, mean MoCA = 21.89, age = 63–90 years, mean age = 76.89[2]) were observed playing a game of Tangram on Osmo, an augmented virtuality MRT, and a game of Young Conker on HoloLens, an augmented reality MRT (Fig. 10.4).

Osmo from Tangible Play is an augmented virtuality MRT with distinct physical and virtual environments for people to interact with separately. The participants interacted with Tangram puzzle pieces in the physical environment to complete the puzzle presented in the virtual environment (tablet). The tablet camera tracks the progress of the participant solving the puzzle in the physical environment and updates the progress in the virtual environment. The virtual environment generates prompts for the participants to solve the puzzle.

HoloLens from Microsoft is an augmented reality technology with overlapped physical and virtual environments. It uses the real physical world of the user to overlay virtual elements (holograms) for the user (who wears the headset) to interact with, see, and hear within their environment (such as workspace and living room). The Young Conker game developed by Microsoft Studio for HoloLens directs the player through various levels in the game where a player is expected to guide a holographic squirrel named Conker through gaze movements, to solve a mystery by performing tasks such as collecting coins, plugging a cable into a socket, and turning on a switch. Conker

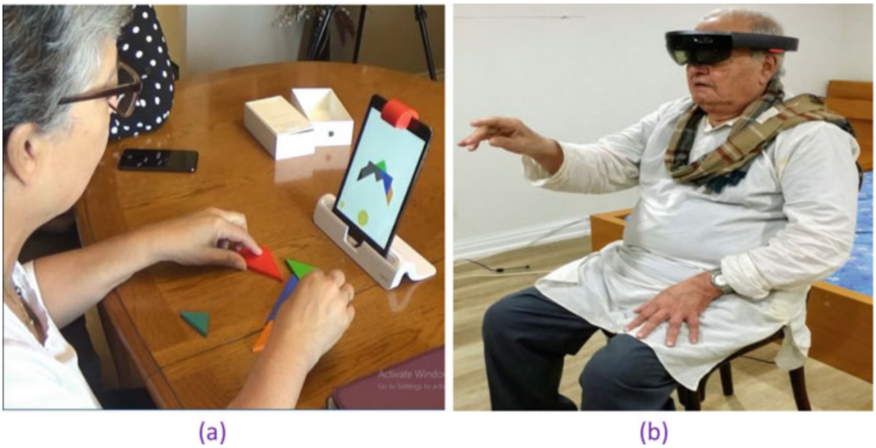
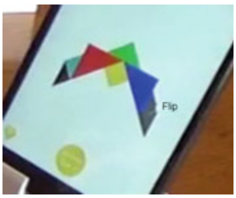


Fig. 10.4 Participants playing a game of **a** Tangram on Osmo and **b** Young Conker on HoloLens (Desai et al. 2019)

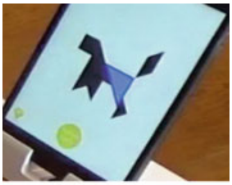
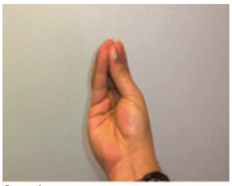
[2]The **MoCA** is a cognitive screening test designed to assist health professionals in the detection of mild cognitive impairment and Alzheimer's disease.

Table 10.9 Features in Osmo and HoloLens related to EFII

Themes identified	MRT type	Interaction	Description
Physical affordance	Osmo		Shape, size, and color used to put the pieces together in a puzzle
Perceived affordance	Osmo	 (a)  (b)	Every time players are successful in completing a puzzle, they earn *gems* (see (a)) which they could use to see prompts while solving a puzzle (see (b)) Players are prompted to use gems to reveal a prompt through an owl speaking in a female voice, a text in a speech bubble, (a) shows gems collected at the end of the puzzle, (b) shows the owl prompting the player to use the gems to receive a prompt. The gem has a number that indicates number of gems available to the player. The circle has a text “Use Gems Cost #”, where # is the number of gems required to generate a prompt for the puzzle
Perceived affordances	Osmo		Yellow, orange, and red ellipses representing easy, medium, and hard levels, respectively. Purple represents the highest level, which the participants did not play in the study
Perceived affordances	Osmo		The Tangram app prompts players to turn over the physical orange Tangram piece when it is not placed with the correct side upwards. The prompt is provided through a text “Flip” on the touch screen near the orange Tangram piece which is still black in the app as the physical piece has not been placed correctly
Perceived affordances	Osmo	Music	Music tone provides feedback to the player about the progress of the puzzle solving task as they put the pieces together

(continued)

Table 10.9 (continued)

Themes identified	MRT type	Interaction	Description
Perceived affordances	Osmo	 (a)  (b)	Flickering between red and blue prompting the participants to use either of the two shapes in that position
Perceived affordances	HoloLens		Tap icon prompting participants to air tap. This is in line with a tap on a mouse to select
Perceived affordances	HoloLens		Air tap to select
Perceived affordances	HoloLens	 *Step 1*  *Step 2*	A bloom gesture to reset HoloLens to Home screen

communicates with the player through speech and gestures/animations. Prompts in the form of text, graphics, and animations are presented to the player to accomplish a set mission in the game.

Four types of prompts were presented by the technologies during game play; textual, graphical, animated, and speech. People interact with the two technologies (Osmo and HoloLens) in the following three ways—gaze (interaction through eye movements), speech, and gestural interactions which included tapping on the touch screen, object manipulations, and hand gestures (air tap and bloom). Table 10.9 shows the features of both Osmo and HoloLens and how they relate to the continuum in Fig. 10.1.

The game play of the participants was video recorded for analysis. Qualitative analysis of the video data was carried out in NVivo™ plus 12.0[3] to identify themes that corresponded to people interacting with the physical and virtual worlds through perception-action sequences without noticing the presence of mediating technology. The ability of MRTs to sustain continuous uninterrupted perception-action loops in an interaction (Hinton 2014), and the extent to which the presence of mediating technologies are familiar to the user, determines the intuitiveness of the interfaces and the interactions. For this to happen, people living with dementia should be able to perceive the prompts presented to them (Desai et al. 2016), and respond to the prompts with correct, often unconscious, actions (Blackler et al. 2010a, b).

The type of MRT—HoloLens and Osmo—was the categorical independent variable. The perception of the prompts and the actions performed by people with dementia in the video data were coded to differentiate when or whether the mediating technology was transparent to people with dementia while they were carrying out the intended task. Distractions caused due to physical/virtual couplings, ergonomics of the mediating technology, prompts that could not be understood by the participants or were understood incorrectly, and incorrect actions performed by the participants were the heuristics used to code the interactions with the MRT.

10.5.2 Results

Two major themes emerged from the analysis of the video recordings of the game play—physical affordances and perceived affordances. The number of occurrences of interactions using physical and perceived affordances is presented in Fig. 10.5. The physical and virtual elements in the mediating MRTs and the games provided clues to people with dementia on possibilities for actions that could be performed.

The results indicate that physical affordances were the prime factor for interacting with Osmo, both with physical and virtual parts of the environment, such that the presence of the mediating technology was not felt by participants. In the absence of

[3]**NVivo** is a qualitative data analysis (QDA) computer software package produced by QSR International.

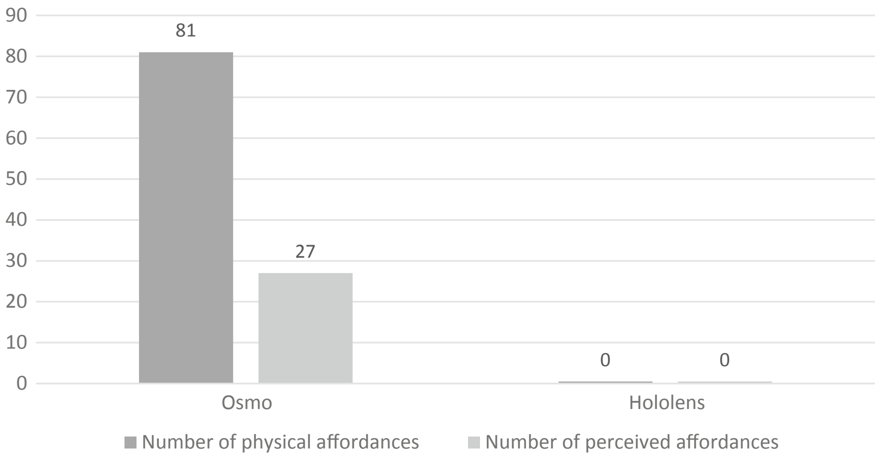


Fig. 10.5 Number of uses of affordances in mixed reality technologies, Osmo and HoloLens

physical affordances, participants used perceived affordances to interact with Osmo. Examples of affordances for both the MRTs are shown in Table 10.9.

Participants found HoloLens difficult to use, both in terms of interactions as well as in terms of understanding the prompts from the technology:

'What is he [Conker] saying?' P1_2001

'Where do I go? What do I do now? I can't find anything?' P8_2008

'It [HoloLens] is very heavy, my head hurts' P4_2004

The affordances in HoloLens and the Young Conker game could not be deciphered by the participants to decide on the actions to be performed in the game. This was due to gestures and interactions with the technology not being familiar; people with dementia found the prompts from the technology difficult to understand and the headset caused distraction and clearly left a red mark on the participants' noses. These issues resulted in the mediating technology not being intuitive to the user.

10.5.3 Discussion

HoloLens and Young Conker did not present any physical affordances to the participants. Although the game app presented perceived affordances in the form of visual images, texts, and animations, people living with dementia were unable to perceive the meaning of these prompts and therefore there were no successful uses of affordances in HoloLens. However, in the case of Osmo and Tangram, the puzzle pieces offered appropriate physical affordances which allowed participants to perform effective actions in the game play. The Osmo game offered the following prompts to enable people with dementia to make correct decisions (Table 10.9); a music tone was played to prompt the participant that a correct block had been placed at the correct place, a visual animation was played in the game to prompt the player on the steps to be performed to complete the puzzle, players were prompted to place a particular block in a position by flickering it between the intended color and gray or two possible options. People living with dementia did not notice these prompts and mostly relied on the physical affordances of Tangram pieces—shape, size, and color—to complete the puzzle. Study 3 found that verbal prompts were effective in getting attention of people with dementia while some of the visual prompts went unnoticed, highlighting how important testing with a relevant user group is to understand which features are familiar and thus transferrable to new interfaces.

The Osmo Tangrams game consisted of three levels; easy, medium, and hard, which were presented through yellow, orange, and red circles, respectively (see Table 10.7). The participants learned the meaning of these circles and used them as perceived affordances as the game progressed. However, these were often forgotten at some stage of the game play, so participants had to be prompted by the researcher verbally and the meaning of the colored circles had to be relearnt. A similar pattern was observed in the use of *gems* to generate *paid* prompts to start a medium or high-level puzzle. An owl emerges on the screen and prompts the player to use gems. However, people living with dementia did not initially understand the concept of the use of gems. They learnt this as the game progressed, but they often had to relearn at some stage of the game as they forgot the meaning. Thus, participants mostly used physical affordances rather than perceived affordances in their interactions with Osmo.

Study 3 found that people living with dementia respond through embodied activities and gestures (physical affordances) more effectively than other interaction modalities. They were able to use the physical affordances of the Tangram pieces to determine the next course of actions to be performed, so the physical affordances in the form of object manipulations offered intuitive interactions in Osmo.

Perceived affordances, as they are learned conventions, require people living with dementia to access population stereotypes, idioms, and metaphors from their long-term memory. Learning new population stereotypes and metaphors requires access to working memory to retain learned conventions. Participants in Study 3 found it difficult to learn and/or remember the new conventions, which explain the increased use of physical affordances over perceived affordances. Thus, mediating technologies that offer access to physical affordances to interact with the technologies are more intuitive to interact with, as in the case of Osmo.

Dementia can affect parts of the brain that control language (Bayles 1982), which helps to explain the effectiveness of non-verbal forms of responses to the prompts such as gestures over speech or language-based interactions. Gestures such as object manipulation and touch screen interactions came naturally to the participants, due to familiarity with other object manipulations (Astell et al. 2016). Gestural interactions such as hand gestures, for example bloom and air tap (Table 10.9), were also effective but only when the participants were prompted by the researcher either verbally or through a hand gesture prompt; the participants found it difficult to remember the gestures as they were unfamiliar with these interactions.

10.6 Overall Discussion

The findings of these three studies suggest that using a framework such as the EFII could help designers to make interfaces more intuitive for people living with dementia, which could help them to live independently for longer, especially if applied to self-care products and services such as in home alarms, fall alarms, and communications technologies, for example. Those features based on the simplest and most ubiquitous pathways such as physical affordances and population stereotypes generally show, in the experiments reported here, better reaction times and lower times on task for people living with dementia than features toward the other end of the continuum, such as features from other domains. Participants living with dementia were found to predominantly use physical affordances when they were available in their interactions with interfaces, and it appears that natural physical and material properties of objects are important drivers of intuitive interactions in people living with dementia.

The affordance is the intrinsic relationship between users and objects, and is theorized as perceptually obvious to any person with the physical capability to use it (Norman 1988; You and Chen 2007). For example, a handle implies grasping. This is why physical affordances are at the lowest end of the continuum, as any physically able person should be able to understand and use them. In Study 3, where physical affordances were available in the test interfaces, people with dementia primarily relied on direct interactions with them. However, the anterolateral entorhinal cortex part of the brain which is responsible for processing spatial information is first affected by Alzheimer's disease (Olsen et al. 2017). Thus, people with dementia due to Alzheimer's disease may not be able to use physical affordances which require them to use spatial knowledge, and physical affordances should be complemented with perceived affordances such as population stereotypes, so that people are able to use their past experience and familiarity to interact with the interfaces intuitively.

Our studies did not directly measure familiarity as information about participants' past experience with technology was not available. However, the results based on coding of participants' behavior with the technology suggest that lack of familiarity with contemporary interaction styles such as the bloom and air tap gestures, or with some of the less common features in the microwave interfaces, presented enormous challenges to people living with dementia. They were also unable to retain information that they learned during the sessions (e.g. the color coding), so it is important for designers to draw on the previous experience of users living with dementia rather than expecting them to learn new interaction modalities.

As Silver (2005) notes, people have learned many conventions: buttons are for pushing, knobs are for turning, switches are for flicking (although direction of on and off varies by country), strings are for pulling, red is for stop, turning a knob on a device in a clockwise direction means to increase and counterclockwise direction means to decrease. Population stereotypes are on the lower side of the continuum because they are common to a whole community and can effectively facilitate users to interact with a product interface intuitively. Interfaces with population stereotypes such as B1, C1, D1, G1 in Study 1 and E2 in Study 2 were familiar for people and allowed participants to use them non-consciously and rapidly at first operation. Participants in Study 3 found it difficult to learn the visual representations of easy, medium, and high levels of the Osmo game as the color codes used were not based on population stereotypes prevalent in North America (red for hard, green or white for easy). However, they were familiar with the stereotypes associated with touch screen interactions such as tapping on buttons or swiping on the screen.

People have an increased tendency to recollect events and memories from the age of 10–30 years (Glück and Bluck 2007), most prominently from the late teens and early twenties. This is referred to as the reminiscence bump. These memories and recollections remain strong for people with dementia until their illness enters an advanced stage (Fromholt and Larsen 1992). Utilizing physical affordances complemented with population stereotypes and familiar interfaces and features (perceived affordances) derived from users' experiences with interfaces and technologies from earlier in their lives may be beneficial for people with dementia. Our findings emphasize the importance of thinking carefully about the familiarity and experience of people living with dementia with the technologies and interfaces they have used in the past. The more familiar the features are and the more ubiquitous they are (i.e. the lower on the continuum they are), the longer they may remain familiar to users living with dementia. We posit that these ubiquitous features which have been long engrained (such as physical affordances and population stereotypes learned in childhood and early adulthood) may remain the longest in memory.

Familiar features in the EFII are connected to users' prior experiences in using similar product interfaces as well as those that may be quite different (e.g. transferred from other domains). In Studies 1 and 2, some of the interfaces with familiar features (A1, C2, and D2) showed better performance than others with familiar features (such as E1, F1, A2, B2, E2, and F2). The domain transfer distance is the distance between the application domain and the source domain of transferred prior knowledge (Diefenbach and Ullrich 2015). As transfer distance increases, people find it increasingly difficult to interpret the features. Domain transfer distance generally increases as you move to the right of the continuum, from similar domains to those that can be far removed from the task at hand (Blackler et al. 2019). For example, in Study 3, participants could not understand the metaphorical text "flip" derived from the metaphorical action of "flipping pancakes" to flip an orange block in the Tangram puzzle. Researchers had to provide a correction to the participants to *turn over* the block, which they were able to understand straightaway.

By seeking to ensure that features are as ubiquitous as possible for this user group (by encouraging use of those from the lower side of the continuum), we hope to assist a wider range of people in accessing their long-term familiarity and experience to use an interface intuitively and for longer.

10.7 Conclusion and Future Work

This work suggests that designers who apply the EFII and create features on the left-hand side of the continuum as far as possible will enable more users to intuitively access their interfaces. Exactly how the pathways to intuitive use in EFII facilitate users with dementia to intuitively interact with product interfaces in the whole process of user-product interaction is worthy of further study. For example, Chen is investigating the influences of characteristics of products' functional images (e.g. metaphors) on intuitive use for users living with dementia. Desai and Astell are further studying prompts with various combinations of sensory modalities that are successful in eliciting correct actions from people living with dementia and the kinds of gestures that are intuitive to use across various stages of cognitive impairment. Blackler is investigating ways to design with and for people living with dementia.

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