



# Combining 2D and 3D Design for Novel Packaging for Older People

Yada Chavalkul \*, Andrew Saxon, and Robert N. Jerrard

Birmingham City University, Birmingham, UK

There has been little research conducted into packaging design recommendations aimed at helping older people understand how to open novel packaging. When developing novel packaging, designers may use their own judgment to provide indications for package opening. Despite this, age-related decline brings about further design needs. Therefore, packaging created by designers may not, at present, be fully appropriate for older people. The study used a participatory methodology which provided rich insights into the process of interaction with novel packaging. Detailed experiential data was collected during participant engagement in opening a range of packaging samples. A combination of qualitative and quantitative data from focus groups further informed the study. Specific relationships between 2D and 3D indications, which appear not to have been previously considered, were examined through semi-structured face to face interviews. The study produced new insights into the use of combined 2D and 3D indications by older people when opening packaging. Both 2D and 3D indications should be combined to present four types of information for package opening. These are: 1) hand positions, 2) hand actions, 3) hand directions and 4) confirmation of both how to open packaging and whether the packaging has been successfully opened. The indications should be provided in three different groups: 1) to fully explain package opening methods, 2) to trigger older peoples' prior experience of similar package opening methods and 3) to explain particular information for package opening.

**Keywords** – Packaging Design, Design for Older People, Open Ability, Cognitive Processes, Affordances, Design Recommendations.

**Relevance to Design Practice** – Combining selected 2D and 3D design approaches provides design recommendations for designers to consider when designing novel packaging. Adopting these design recommendations makes it easier for older people to understand how to open novel packaging.

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## Introduction

Studying the ability to open packaging is crucial because it contributes directly to users' ability to access the contents. For older users whose physical ability has declined, opening a package can be increasingly difficult. Opening difficulties have been observed in relation to age-related decline in sensory (Cayton, 1995; Moore, 1993), cognitive (Carse, Thomson, & Stansfield, 2007; CEN/CENELEC, 2002; Mawle, 2003; Woodcock, Torrens, & McDonagh, 2004) and hand (Blakey, Rowson, Tomlinson, Sandham, & Yoxall, 2009; Janson, Yoxall, & Hayes, 2005; Lewis, Menardi, Yoxall, & Langley, 2007; Yoxall, Kamat, Langley, & Rowson, 2010) functions. However, there is a paucity of research into the cognitive functions concerned with older peoples' ability to understand how to open packaging. This study revealed that the use of combined 2D and 3D indications plays a significant role in helping older people understand how to open novel packaging.

In this study, 2D and 3D indications are identified by senses used to perceive indicated meanings. Two dimensional indications (2D) refer to surface, embossed or imprinted indications which users can see and read to interpret meanings. These indications are, for example, written instructions, a diagram or an embossed arrow. Three dimensional indications (3D) refer to shape, embossed or imprinted indications which users can see and feel to interpret meanings. These indications are, for example, the shape of a trigger, ridges around a lid or the imprinted marks corresponding between the lid and the body of packaging,

suggesting that the packaging is open. An embossed arrow is defined as a 2D indication because its meaning is perceived by seeing rather than feeling. Those imprinted marks are seen as 3D indications because their meaning can be perceived by feeling.

## Older People, Packaging and Opening Ability

Aesthetics and safety are important design requirements for packaging (Moore, 1993; Oostendorp, Bode, Lutters, & Houten, 2006). Aesthetics is a fundamental design requirement for attracting consumers' attention and for presenting the quality of contents. Safe packaging closures protect the quality of contents (e.g., food and drink) (Berns, 1981; Duizer, Robertson, & Han, 2009) and ensure that particular groups of contents such as medicines are not accessed accidentally by children (de la Fuente & Bix, 2005).

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\*Corresponding Author: appphd\_yada@yahoo.com

However, closures designed for packaging aesthetics and safety may be problematic for older people. For example, it is difficult for some to see precisely where to start removing a transparent plastic film wrapped around the lid of a jar (Keates & Clarkson, 2003). A child-resistant closure, which requires users to squeeze the lid first and then to turn it, presents older people with particular difficulties (Carse et al., 2007; Moore, 1995).

The importance of package opening ability was highlighted by the then UK Department of Trade and Industry<sup>1</sup> (DTI) (1999) reporting that in the UK, 39% of accidents related to packaging in 1994 were associated with opening. The DTI (1999) stated that users used inappropriate tools such as knives, pliers and screwdrivers to open difficult packaging. Compared with younger users, older users have greater physical decline and therefore, appear to be at greater risk of having accidents when using such tools. Winder, Ridgway, Nelson, and Baldwin (2002) suggested that unclear indications for opening can cause user frustration, leading to adoption of risky opening strategies. Experiencing opening difficulty can also lead to negative feelings about packaging and contents. Galley, Elton and Haines (2005) noted that users may not repurchase a package that was difficult for them to open.

Design measures that increase opening ability taking into account sensory (Cayton, 1995; Moore, 1993) and hand impairments (Blakey et al., 2009; Janson et al., 2005; Lewis et al., 2007; Yoxall et al., 2010) are well established. Previous research into the cognitive functions of opening ability relates to emotions (Woodcock et al., 2004), attitudes (Carse et al., 2007) and remembering (Mawle, 2003), but not specifically to *understanding* how to open packaging. In Europe, CEN/CENELEC Guide 6 (CEN/CENELEC, 2002) suggested certain characteristics of indications for opening required in relation to

older peoples' sensory and cognitive impairment. However, these guidelines did not address how to design such indications in order to create effective package opening for older people.

A newly designed opening mechanism may offer new packaging features, for example, safety or ease of use. Moore and Nayak (1992) noted that unfamiliar packaging with unfamiliar opening mechanisms may be difficult for older people to understand. Therefore, it was also essential to study older peoples' requirements to ensure that such packaging is easy for them to open (Moore & Nayak, 1992).

## Novel Packaging and Older People

Novel packaging refers to a package whose appearance is unfamiliar to consumers. One of the commonly held stereotypes about older people is that they are not willing to change and are not likely to try new experiences (Stroud, 2005). Such views falsely maintain that older peoples' resistance to change may form a barrier, preventing them from trying new products in novel packages.

Stroud (2005) suggested that older people are unlikely to try new brands. Cole and Balasubramanian (1993) noted that older people have higher brand loyalty than their younger counterparts. Thus, they tend to buy a product with a brand that they know and a package that they are familiar with.

There is however, another view, that older people try new products just as younger people do, but are driven differently (Leventhal, 1997; Thompson & Thompson, 2009). Younger people may look for new products that are trendy, whereas older people tend to look for new products that meet their personal, specific needs (Leventhal, 1997).

Stroud (2005) stated that older peoples' willingness to try new brands may decline, but not in all cases. Older people are also willing to try new brands that meet their needs (Ambrosius, 2010).

Furthermore, self-perceived age tends to be more useful than chronological age in understanding older people's product and brand consumption (Wilkes, 1992). Gana, Alaphilippe, and Bailly (2004) stated that self-perceived age refers to how old a person feels she or he is. Older people with a younger self-perceived age tend to be open-minded in trying new products and brands (Schiffman & Sherman, 1991).

Despite older peoples' preferences for products with tried and tested branding, it is unlikely that they can completely avoid experiencing new products. All products have a life cycle (Onkvisit & Shaw, 1989); even though some products may survive in the market for many years, finally, they will become less and less popular (Onkvisit & Shaw, 1989). Outdated products are replaced by new ones, often with enhanced packaging. In the first stage of product decline, a brand owner may employ a minor change to extend product life by changing its packaging: marketing an old product and brand in a novel package for example. In this case, older consumers may have to accept a novel package, if they prefer to continue using the same brand and product with which they are familiar.

**Yada Chavalkul** is a doctoral researcher at Birmingham Institute of Art and Design, Birmingham City University. Her design practice and research areas are in graphic and packaging design. Yada's masters degree research related to the use of 2D design composition to communicate characteristics in graphic design. This paper, drawn from her doctoral research, focused on the use of 2D and 3D design to communicate to older people how to open novel packaging.

Dr. **Andrew Saxon** is Director of e-learning at Birmingham City University Institute of Art and Design, and a University Senior Learning and Teaching Fellow. His research interests lie in the application of arts-based models of designing to software user interface development, and the evaluation of the software user interface and user experience design for software. The main focus of this work has been toward web and multimedia software. He is also involved in the development of e-learning initiatives within the Institute Learning and Teaching Centre, which he leads. These include the design and evaluation of reusable learning objects, and research into e-pedagogies for art and design. He supervises Doctoral and Masters students in the School of Visual Communication, where he is research coordinator.

Dr. **Robert N. Jerrard** is the Emeritus Professor of Design Studies, previously Director of the Research Centre for Design and the Creative Industries at Birmingham City University (BCU), Institute of Art and Design. He has published widely on theoretical and social aspects of design and technology. He is a Fellow of the Design Research Society, an Associate Editor of the Design Journal and a member of the Arts and Humanities Peer Review College. Dr. Jerrard was the Principal Investigator of the major AHRC research project concerning Risk, Risk Perception and Design. He has directed major research into Fashion Culture and Consumption and Work-based Learning in Art and Design. He is a research consultant for a number of international publishing groups and several UK and overseas universities.

## Older People and Their Demography

Older people in this study were defined by chronological age and are all 65+. Three kinds of ageing are typically defined: biological (Birren, 1964; Birren & Renner, 1977), psychological (Birren, 1964; Birren & Renner, 1977) and chronological age (Clarke, 1993; Tinker, 1997; Windmill, 1990). However, defining the biological and the psychological age of a person is likely to be highly problematic, for example, by measuring the ageing of each organ (e.g., the brain) and body system (Stokes, 1992).

In gerontology, there are various opinions on the start of *old age* including age 55 (Neugarten, 1974), 60 (Stuart-Hamilton, 2000), and 65 (Stokes, 1992; Victor, 2005; Whitbourne, 2001). Older people aged 65+ are more likely to be affected by age-related decline and to have greater difficulty in opening packaging than those 5-10 years younger.

The World Health Organization (WHO) (2002) reported that by 2025, one third of the population in developed countries will be aged 60+. In the UK, the Office for National Statistics (ONS) also estimated that there would be a 63 % increase in people aged 65+ in the next 21 years (Dunnell, 2007). In the UK, there has been an increase in the number of older people living alone (ONS, 2005). Thompson and West (1984) and Coleman (1996) noted that it is very important for older people to be independent. This is because being physically dependent on others can cause older people anxiety (Coleman, 1996; Fiske, 1980).

## Packaging Opening

The interaction between consumers and packaging comprises three stages: purchasing, using and disposing. The *using* stage can be divided into: carrying, storing, opening, dispensing and closing. The interaction between consumers and packaging in this stage can vary, lasting from only a few minutes after purchase to up to a month, depending on product types; for example, a chocolate bar or a bottle of washing up liquid. In some cases, the using stage can be further sub-divided into: initial opening and reopening, dispensing and re-dispensing, and closing and reclosing (Winder, 2006), as shown in Figure 1.

In some packages, the boundary between opening, dispensing and closing is relatively blurred. For example, the appearance of some trigger spray bottles does not clearly show whether or not the bottle is open. In such cases, dispensing the contents is the only reliable way for the user to confirm that the bottle is open or closed and whether the contents are accessible. Consequently, opening in this study also included the stage of dispensing contents. Closing can be seen as a reverse stage of opening.

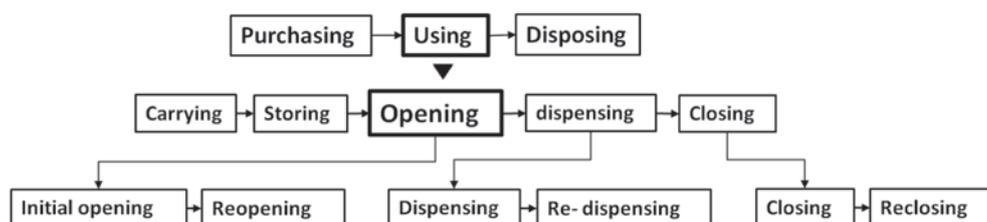


Figure 1. The stages of using packaging.

## Older Peoples' Age-Related Decline in Relation to Opening Ability

Opening a package tends to involve both strength and movement of hands and fingers. Thus, physical limitations in relation to hand strength or dexterity can lead to difficulty. However, before a package is physically opened, other processes, for example, receiving information from the package and thinking about how to open it, are also required. Therefore, the major processes of opening a package may involve three stages: 1) receiving the information, 2) thinking about how to open it and 3) performing package opening. The first stage uses sensory organs as a combined channel for information input. The second stage relates to cognition, leading to the last stage where the package is physically opened.

### Sensory Functions

The sensory functions used when opening packaging are vision, hearing and touch. Impairment, which can adversely affect older peoples' ability to understand how to open a package, concerns these three sensory functions, identified respectively as follows:

- Visual acuity, colour perception and brightness and darkness adaptation
- Hearing sensitivity
- Tactile and pressure sensitivity

Decline in visual acuity makes reading difficult (Watkinson, 2005) especially small print (Pirkl, 1994). Changes in colour perception may reduce the ability to distinguish the colour of indications for opening on a package. As a result of declining brightness and darkness adaptation, high colour contrast (Pirkl, 1994) between indications and background is needed to make it easy to identify the indications.

Decline in hearing sensitivity caused by ringing, hissing or buzzing noises in the ear (Kart, Metress, & Metress, 1978; Parsons & Felton, 1990) may hinder the ability to receive audible information from packaging that would otherwise aid opening.

Decline in tactile and pressure sensitivity may reduce the ability to receive information from packaging for opening. Tactile sensitivity is concerned with the shape and texture of an object (Pirkl, 1994), for example, when feeling a recessed shape on a lid. Pressure sensitivity involves how hard or soft an object is as users press on it with their fingers or hands (Pirkl, 1994). For example, users can feel through their fingers the soft pressure reaction when pressing an unlocked trigger.

## Cognitive Functions

Cognition in this context comprises a number of processes, seen differently by different authors (Benjafield, 1992; Smyth, Collins, Morris, & Levy, 1994; Solso, 2001). However, cognitive processes described by Smyth et al. (1994), Solso (2001) and Welford (1980) all include: perception, memory and understanding. Perception is the stage by which a person examines sensory stimuli before making the decision whether or not to respond (Cunningham & Brookback, 1988). Through application of memory, previous knowledge helps a person classify old and new information (Benjafield, 1992; Smyth et al., 1994). Understanding then takes place through the integration of old and new information (Smyth et al., 1994; Welford, 1980). From this integration, ideas are constructed for decision making (Smyth et al., 1994; Welford, 1980). Subsequently, the experience from these cognitive processes can be used as a basis for future packaging use (Smyth et al., 1994).

## Perception

Age-related impairment of seeing, touching and hearing is likely to contribute to the deterioration of perception. Therefore, stronger sensory stimuli are required for older people (Stokes, 1992). For example, larger text sizes and high colour contrasts between text and background will help older people read written instructions.

## Memory

Semantic memory which refers to knowledge and facts about the world (Smith, Norris, & Peebles, 2000) tends to be stable with ageing (Stokes, 1992), declining eventually at 75+ (Bäckman, Small, Wahlin, & Larsson, 2000). White (1993) explained that semantic memory, or what a person has learned, helps a person learn new things. Semantic memory, therefore, may be useful when opening both familiar and unfamiliar packaging.

Working memory is used to manipulate stored information in the planning of a task (Kensinger & Corkin, 2003; Stokes, 1992) and declines with ageing (Craik & Bosman, 1992; Kensinger & Corkin, 2003; Stokes, 1992). Kensinger and Corkin (2003) explained that the decline of working memory in older people may be caused by three kinds of cognitive limitations. Firstly, older people take longer to process information. Secondly, they find it difficult to simultaneously store different types of information. Thirdly, it is difficult for them to distinguish relevant from irrelevant information. Therefore, a complex opening task may be difficult for older people because they have to store, update and retrieve information from a number of indications, for example, diagrams, symbols and shapes, in order to understand how to open the package.

## Understanding

The Oxford English Dictionary defined intelligence as *the faculty of understanding* (Simpson & Weiner, 1989). Cattell (1963) and Bäckman et al. (2000) indicated that there are two kinds of intelligence: fluid and crystallised. Fluid intelligence involves

the ability to reason, acquire new ideas (Stokes, 1992) and solve new problems (Bäckman et al., 2000). Crystallised intelligence is concerned with specific knowledge and methods for solving problems (Cunningham & Brookback, 1988).

Fluid intelligence declines with ageing (Bäckman et al., 2000), but crystallised intelligence appears to be efficient (Stokes, 1992) until around the age of 75 (White, 1993). Therefore, older people may successfully draw on previous knowledge to help them understand how to open a familiar package, whereas understanding how to open an unfamiliar package may not be easy.

## Hand Functions

Decline of hand functions mainly relates to physical impairment of the hand structures, for example, in muscles, tendons and bones (Carmeli, Patish, & Coleman, 2003). Additionally, osteoarthritis (Aigner, Haag, Martin, & Buckwalter, 2007; Estes, Bochenek, & Fassler, 2000) and rheumatoid arthritis (Reginster, 2002); which both affect certain joints, are commonly found in older people. Osteoarthritis (Altman et al., 1990) and rheumatoid arthritis (Symmons et al., 2002) cause pain, swelling, stiffness and deformation of fingers. This makes it difficult to move wrists and fingers (Carmeli et al., 2003). Hand impairment can also lead to limitations in the hand strength available to squeeze a lid or restrictions in hand movement sufficient to prevent turning the lid of a jar.

## Inclusive Design and Design for Older People

Packaging design practice for older people within the terms of this study appears to subscribe to the principle of inclusive design. Keates and Clarkson (2003, preface) suggested that “Inclusive design is about maximising the market potential of your products by making sure that the maximum number of people can use them”. Although this study specifically excluded older people who have severe impairments such as blindness, the design recommendations offered herein can be used to design packaging so that a greatly expanded range of users will be able to open packaging. As the motto of the Centre of Applied Gerontology at the University of Birmingham, which collaborated in this study, states: “design for the young and you exclude the old; design for the old and you include the young”.

User-centered and participatory design are important aspects of inclusive design in which user needs are taken into account during the design process. The difference between participatory design and user-centered design may be recognised through the different degrees of user involvement. In participatory design, users are seen as co-designers (Abrams, Maloney-Krichmar, & Preece, 2004). In user-centered design, users provide design requirements for designers, but do not make design decisions (Iivari, 2004).

In this study, design can be used to improve packaging, compensating for older peoples’ decline in visual, cognitive and hand functions. Thus, older users’ involvement during the design

process as co-designers is important in ensuring that packaging meets their needs.

## Participatory Design Methods

Data were collected from participants through three stages: initial observations, focus groups and in-depth interviews.

### Initial Observations

The purpose of the initial observations was to gain better understanding of how older peoples' reduced ability affects their everyday activities. The initial observations were conducted in social settings (two lunch clubs where older people aged 80+ and 60+ attended), during activities provided by the UK charity, Age Concern<sup>2</sup>. During these sessions participants exhibited limitations in varying degrees in terms of vision (Ah-Chan & Downes, 2006; Chivers, 2003; Watkinson, 2005), hearing (Gates & Mills, 2005; Stuart-Hamilton, 2000), short-term memory, mobility (Daley & Spinks, 2000; Metz, 2000) and hand dexterity (Carmeli et al., 2003), when taking part in lunch club activities. Such limitations may affect their ability to open packaging. Decline in short-term memory was only found in a few of the attendees aged 80+. Short-term memory can be described as limited-capacity storage of information over a very short duration (Kensinger & Corkin, 2003). However, Kensinger and Corkin (2003) suggested that ageing is unlikely to negatively affect short-term memory, consequently the observed memory limitations may have other causes.

The attendees of lunch club one (80+) tended to have more severe degrees and various kinds of age-related impairment than those in lunch club two (60-80). The older people become, the more vulnerable and dependent they are likely to be (Minkler, 1994; Tomassini, 2005). To ensure that participants with different levels of limitations were accommodated in this study, they were categorised by age groups. The researcher also learned that opening ability related to prior knowledge of how to open packaging and indications. This was examined further in the focus groups.

### Focus Groups

The purpose of the focus groups was to identify design requirements that would increase the intelligibility of package indications for older people.

### Participants

Twelve participants, six females and six males from three age groups (65-74, 75-84 and 85+), were selected for two focus groups from the members of *the Thousand Elders*<sup>3</sup> at the Centre for Applied Gerontology .

### Packaging Samples

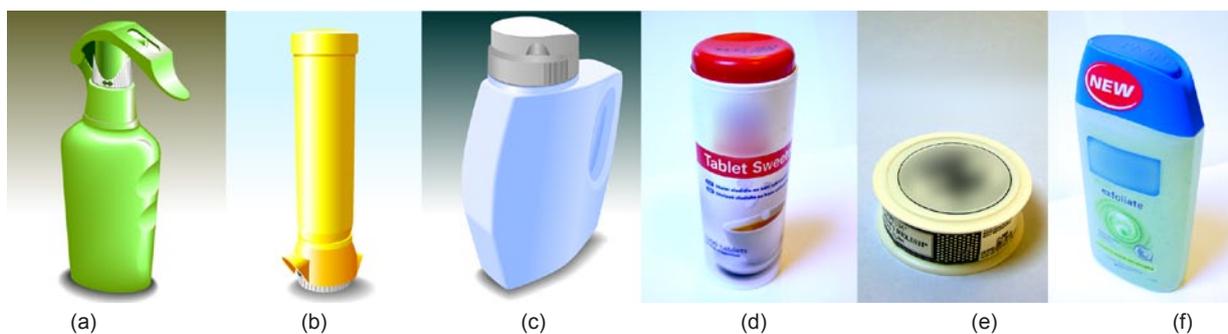
Three criteria used for selection of packaging samples were: 1) types of packaging most used by older people, 2) unfamiliar relationships of indications to opening methods and 3) a variety of indications and opening methods.

The types of packaging most used by older people appeared to be packaging for food and household products (e.g., household cleaning and personal care products). Older people spend a greater proportion of their total expenditure on these product categories than others (ONS, 2008).

This study focused on how to design indications that effectively explain to older people how to open novel packaging. Hence, packaging with an unfamiliar relationship of indications to opening methods was examined. To identify such packaging, the relationship of indications to opening methods commonly found in different types of existing packages in supermarkets was categorised and indexed. Packaging where the relationship of indications to opening methods was different from the categorisation index was selected for use in the focus groups.

Also, the packaging samples in this study were all plastics because the greatest variety of indications and opening methods was found in this material.

There were 13 different kinds of opening methods among the 23 packaging samples selected. In each of these, the sample whose appearance differed most from the packages in the categorisation index explained above was selected. Full discussion of all 13 packaging samples may cause older participants to tire when contributing during the session; this could have negative implications for the data. Therefore, six of the 13 samples were chosen at random for use in the focus groups. The remaining seven were used in the in-depth interviews. After careful consideration, these were felt to provide a true-to-life representation of everyday experience for the research which was unlikely to be altered by the use of different selection criteria. The six samples are shown in Figure 2 below.

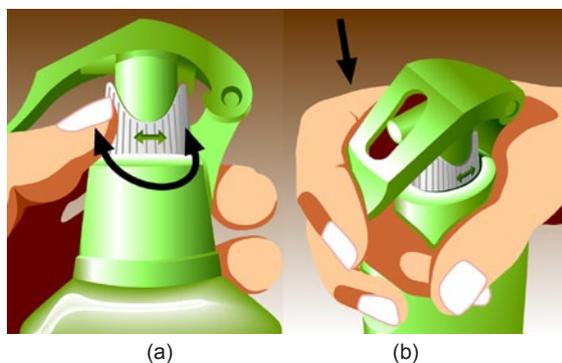


**Figure 2. Six packaging samples for the focus groups.**

(Illustrations were used to show packages in Figures 2(a), 2(b) and 2(c) as permission of using the photos was not granted.)

Two focus groups were conducted. The first group discussed packaging that its participants found the easiest to understand how to open. The second group, in contrast, discussed packaging that its participants found the most difficult to understand how to open. The average score value provided by participants for the factor of *understanding* was used to identify these two packages. Participants were asked to try opening the same six packaging samples to provide the score. Therefore, all participants had experience of opening whichever packaging sample was subsequently selected for discussion. The easiest and most difficult packaging samples appear as Figures 2(a) and 2(d) above.

Package 2(a) is a sun spray bottle. The opening process of this package has two stages: 1) releasing the lock of the trigger by turning the white collar anticlockwise or clockwise (see Figure 3a) and 2) dispensing the contents by pressing the trigger (see Figure 3b).



**Figure 3. (a) Turning the white collar anticlockwise or clockwise and (b) pressing the trigger to dispense the contents.** (Illustrations were used to show how to open package 2(a) as permission of using the photos was not granted.)

Package 2(d) is a tablet sweetener bottle. The opening process of this package has two stages: 1) removing the seal on the base of the package (see Figure 4a) and 2) dispensing the contents by pressing the lid (see Figure 4b).



**Figure 4. (a) Removing the seal on the base of the package and (b) pressing the lid to dispense the contents.**

### Procedure

There were two sessions in each of the two focus groups. In the first session, participants were asked to complete two questionnaires, both of which collected quantitative data. The first questionnaire concerned participants' health-related conditions affecting their ability to open packaging, for example, visual impairments or arthritis. The second questionnaire asked participants to use Likert scales to rate the six packaging samples on three factors: familiarity, understanding and ability to physically open the packages. The score provided by participants for the factor of *understanding* was used to select the easiest package for discussion in focus group one and the most difficult package for discussion in focus group two. This discussion took place in the second session; mostly qualitative data were collected.

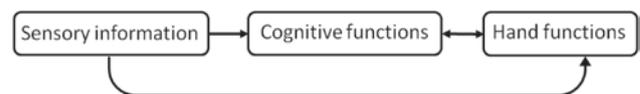
Two and three dimensional indications on the selected packaging samples used in the focus groups are shown below in Table 1.

### Results and Discussion

The literature showed that ageing affects visual (Ah-Chan & Downes, 2006; Chivers, 2003; Watkinson, 2005), cognitive (Craik & Bosman, 1992; Kensinger & Corkin, 2003; Stokes, 1992) and hand functions (Carmeli et al., 2003). The findings from the focus groups indicated that age-related decline in these functions negatively influenced the participants' ability to understand how to open the packaging samples.

The findings from the focus groups showed that there are interplays between sensory information, cognitive functions (understanding) and hand functions (Benjafield, 1992; Birren, 1964; Goldstein, 1980; Schonfield, 1980; Smyth et al., 1994; Solso, 2001; Stokes, 1992; Welford, 1980). The quality of sensory information influences cognitive functions and hand functions; cognitive functions influence hand functions and hand functions also influence cognitive functions (understanding and emotional responses) as illustrated in Figure 5 below.

The findings from the focus groups also provided insights into sensory, cognitive and hand functions that led to the formulation of design recommendations aimed at helping older people understand how to open packaging.



**Figure 5. The relationship between sensory information, cognitive functions and hand functions.**

### Sensory Functions

The data from the focus groups revealed that the key design recommendation concerning sensory functions is *visibility of indications* (CEN/CENELEC, 2002; Jordan, 1998; Norman, 2002). The data from the focus groups also showed that visibility of indications can be achieved by using colour (CEN/CENELEC, 2002; Moore, 1993), size (CEN/CENELEC, 2002; Moore, 1993), position (CEN/ CENELEC, 2002; Galley et al., 2005; Moore,

**Table 1. Two and three dimensional indications on the selected packaging samples used in the focus groups.**

Packaging samples	2D indications	3D indications
 <p>Package 2(a)</p>	 <p>The product name</p>  <p>The two-headed arrow</p>	 <p>The ridges around the collar</p>  <p>The trigger</p>  <p>The grooves</p>  <p>The nozzle</p>
 <p>Package 2(d)</p>	 <p>The product name</p>	 <p>The lid and the body</p>

Note: Illustrations were used to show 2D and 3D indications on package 2(a) as permission for using the photos was not granted.

1993), design layouts and typography (Bix, 2002; Galley et al., 2005; Moore, 1993), but avoiding placing indications on shiny surfaces (CEN/CENELEC, 2002). Further design solutions concerning the visibility of 2D and 3D indications drawn from the focus groups are now summarised.

Colour contrast and position are important design attributes for both 2D and 3D indications, whereas size, design layouts, typography and shiny surfaces are likely to be important for 2D indications.

Because of the limited space on packaging, 2D indications such as written instructions tend to be small. Three dimensional indications can be divided into large and small sizes. Large indications might include the lid or the body of a package. Small indications might include indentations in the body of a package. Colour contrast between indications and background and position (e.g., near the opening) are likely to have more of an effect on the visibility of 2D indications and small 3D indications than they are on the visibility of large 3D indications. Indication

size appears to have more of an effect on the visibility of 2D indications than it does on small and large 3D indications. No participants commented that size affected the visibility of small 3D indications. The visibility of small 3D indications tends to be more affected by colour contrast than by size.

Design layouts and typography can make long instructions (2D indications) easy to read and understand. A shiny surface, negatively affects the readability and visibility of 2D indications. For example, embossed arrows (2D indications) are identified with difficulty when they are on a shiny surface.

The data from the literature suggested that alternative indications formats, received by feeling and hearing (CEN/CENELEC, 2002; Hartson, 2003; Jordan, 1998) should be provided for older people who may find it difficult to see or read indications. It should be noted that older people who have severe visual impairment were excluded from the focus groups, so that cognitive processes related to participants' understanding of how to open packaging could be fully explored with no data skewing

due to such impairments. Participants appeared to mainly rely on the visual indications followed by the tactile indications then the audible indications when opening the packaging samples.

### *Cognitive Functions*

The data from the focus groups revealed that key design recommendations to promote the understandability of packaging information for opening related to a) the explanation of how to open packaging (Monö, 1997; Norman, 2002), b) the prioritisation of information for opening (Jordan, 1998) and c) the relationship of indications to required opening methods (CEN/CENELEC, 2002).

The literature reviewed (Monö, 1997; Norman, 2002; Jordan, 1998) includes communications of how to use products. The findings from the focus groups provided specific design recommendations concerning the communication of how to open packaging.

The data from the focus groups showed that explanations of how to open packaging related to a) the identification of packaging types which suggest required opening methods and b) detailed information for opening (e.g., required hand directions). Prioritisation of information for opening involved a) highlighting the importance of indications by using colour and b) prioritising information on packaging labels, including opening instructions, by using design layouts: for example, sizing text instructions, grouping information spatially and sequentially numbering the opening steps.

The relationship of indications to the required opening methods related to older peoples' interpretation of indications on how to open packaging. Older peoples' prior experience formed stereotypes of past relationships of indications to opening methods. It is easy for older people to understand how to open packaging when the stereotypes are familiar because they recognise that particular packaging, from its appearance (indications), requires certain opening methods. The data from the focus groups also showed that familiar packaging appearances (indications) misled participants that a particular opening method was required, when it was not. Additional indications are needed for novel packaging which employs a new method for opening, to help older people understand how to open it.

### *Hand Functions*

The findings from the focus groups indicated that the shape of packaging affects older peoples' ability to physically open packaging (Berns, 1981). Opening methods that require excessive hand actions should be avoided (CEN/CENELEC, 2002) and opening mechanisms should allow users to physically open packaging as guided by indications (Norman, 1999). In the focus groups, the grooves on one packaging sample allowed participants to hold the bottle firmly and exert hand strength to open it. Additionally, the hand action required to dispense the content from another packaging sample, pressing the whole package down onto the atomiser at the bottom of the package, caused a participant hand pain as this required an excessive wrist movement. Such hand actions may inhibit older peoples' ability to

successfully open a package and to evaluate their understanding of how to open it. Furthermore, the data from the focus groups revealed that in some cases, indications successfully guided participants on how to open the packaging sample, but opening mechanisms did not allow them to open it easily.

The focus groups highlighted the crucially related roles of 2D and 3D indications in guiding participants' understanding of how to open the packaging sample. The use of 2D and 3D indications was examined further in the in-depth interviews.

### **In-depth Interviews**

The purpose of the interviews was to identify in detail how participants used 2D and 3D indications to understand how to open packaging.

### *Participants*

Six participants, three females and three males; in three age groups, 65-74, 75-84 and 85+, were selected from the focus group participants. Different packaging samples were provided for the participants in the interviews. Therefore, the experience gained by the participants from the focus groups was unlikely to negatively affect any new data. In contrast, the participants' understanding of the broad context of the study from the focus groups may have helped them contribute in-depth data about opening ability.

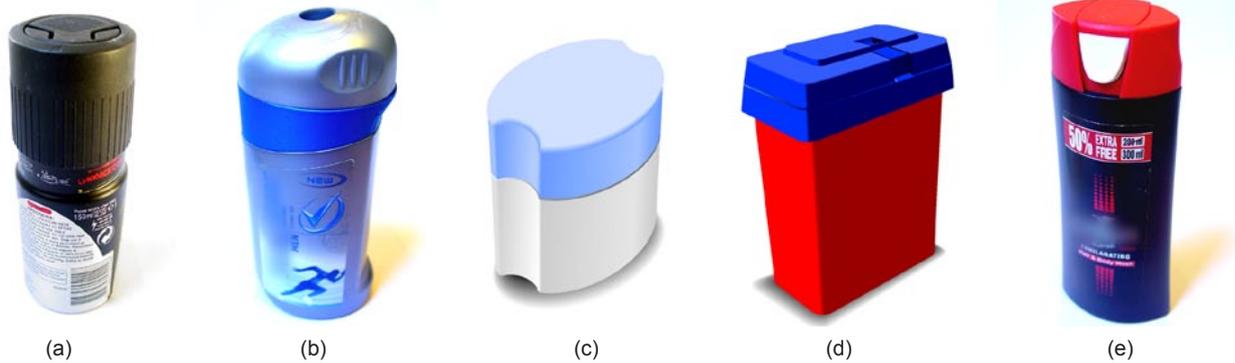
### *Packaging Samples*

The two criteria used for selecting packaging samples were unfamiliarity and difficulty in understanding how to open packaging. In the focus groups, the researcher noticed that the participants commented more on the packages which they had difficulty understanding how to open than the ones they found easy. Additionally, packaging samples with two or more opening steps or unfamiliar opening methods tended to demand more cognitive processing. Unfamiliar opening methods were defined as the packaging samples whose opening methods were different from the ones presented in the categorisation index established in the focus groups.

Accordingly, seven out of the original 13 packaging samples which were not used in the focus groups were shortlisted. Afterward, five out of the seven packaging samples which have two or more opening steps or unfamiliar opening methods were chosen for use (see Figure 6).

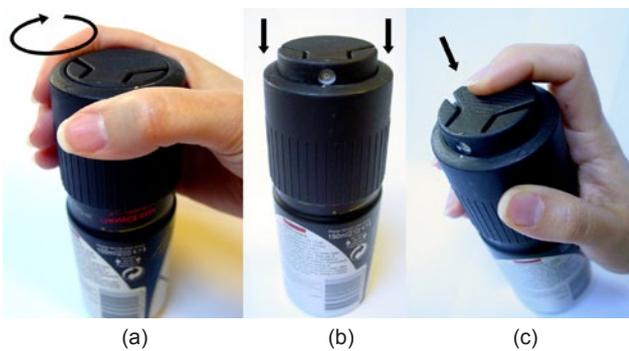
Only one of the five packaging samples was selected for the in-depth discussion. This package was the most unfamiliar to each participant and the most difficult for them to understand how to open. This discussion was to provide insights into cognitive processes employed when older people used indications to open packaging. Package 6(a) was selected for two participants; package 6(b) was selected for the remainder.

Package 6(a) is a deodorant bottle. The opening process of this package has two stages: 1) releasing the lid by twisting it clockwise (see Figure 7a) so that the outer part of the lid moves down to reveal the atomiser and nozzle (see Figure 7b) and 2) dispensing the contents by pressing the atomiser (see Figure 7c).



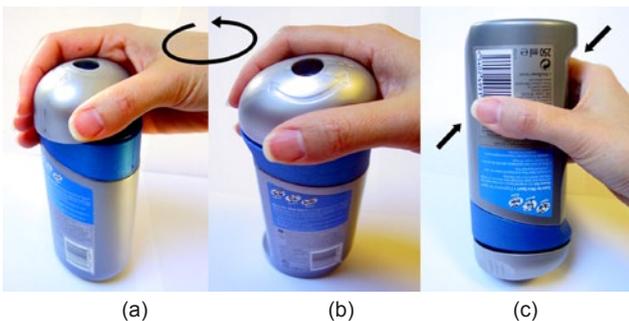
**Figure 6. Five packaging samples for the in-depth interviews.**

(Illustrations were used to show packages in Figures 6(c) and 6(d) as permission for using the photos was not granted.)



**Figure 7. (a) Twisting the lid clockwise, (b) the outer part of the lid moving down and (c) pressing the atomiser to dispense the contents.**

Package 6(b) is a shower gel bottle. The opening process of this package has two stages: 1) releasing the lid by twisting the lid anticlockwise (see Figures 8a-8b) and 2) dispensing the contents by turning the bottle upside down and squeezing it (see Figure 8c).



**Figure 8. (a) and (b) Twisting the lid anticlockwise to release the lid and (c) turning the bottle upside down and squeezing the bottle.**

### Procedure

Qualitative data were collected in the two individual interview sessions. In the first of these, observations were made during the participants' interactions with the packaging samples. The researcher made careful journal notes and video recordings of all aspects of the interactions for later use. Participants were also asked to complete two questionnaires using Likert scales

to rate the packaging samples on two factors: familiarity and understanding. The score was used to select the package that the participants found the most unfamiliar and the most difficult to understand how to open.

In the second session, the information derived from the journal and confirmed by that from the video recorder was used to inform specific inquiries into the participants' interactions with the selected package in the subsequent discussion.

Two and three dimensional indications on the selected packaging samples used in the in-depth interviews are shown below in Table 2.

In both the focus groups and the in-depth interviews, the researcher informed the participants that the purpose of trying to open the packaging samples was not to test their ability to open the packages, but to gather their comments to develop design recommendations for packaging related to older people and opening ability. Designing the questionnaires required specific considerations around the page layout, the font and the type size to ensure that it was easy for participants to read and respond to.

## Results

The findings from the in-depth interviews referred to the use of 2D and 3D indications that helped participants understand how to open the packaging samples. The indications can be categorised into three groups according to the types of information that the indications present.

- Group one refers to 2D *full explanation* indications (e.g., diagrams and written instructions), showing all hand positions, hand actions and hand directions required for opening and confirmation of how to open packaging.
- Group two relates to 2D and 3D *memory trigger* indications (e.g., product names and atomisers), identifying methods of opening by triggering users' prior experience and showing all hand positions, hand actions and hand directions required to release the lid and/or dispense the contents.
- Group three refers to 2D and 3D *partial explanation* indications (e.g., arrows and indentations), partially showing information for opening a package, for example, hand positions and hand actions required for releasing the lid, but not hand directions.

**Table 2. Two and three dimensional indications on the selected packaging samples used in the in-depth interviews.**

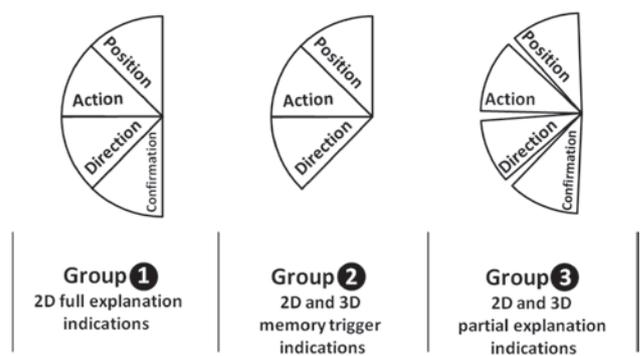
Packaging samples	2D indications	3D indications	
 <p>Package 6(a)</p>	 <p>The product name</p>	 <p>The lid and the body</p>	
	 <p>The diagrams</p>	 <p>The ridges on the top</p>	
	 <p>The arrows</p>	 <p>The ridges around the lid</p>	
			 <p>The atomiser and the nozzle</p>
			 <p>The indented base</p>

**Diagrammatic Analysis of the Use of 2D and 3D Indications When Opening a Package**

The categories of 2D and 3D indications (full explanation, memory trigger and partial explanation) are represented diagrammatically in Figure 9.

There are four types of information linked to package opening: hand positions, hand actions, hand directions and confirmation of both how to open packaging and how to assess whether the packaging has been successfully opened. Full explanation and partial explanation indications include these four, whereas memory trigger indications comprise only hand positions, hand actions and hand directions required for opening a package (see Figure 9).

Full explanation and memory trigger indications show complete information for opening, including hand positions, hand actions and hand directions, whereas partial explanation indications only partially achieve this. Hence, the pattern in Figure 9 demonstrates a connection of four segments in the first semi-circle (full explanation indications) and of three segments

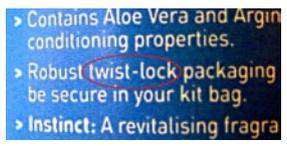


**Figure 9: The pattern presenting the use of 2D and 3D indications.**

in the middle semi-circle (memory trigger indications), but a slight separation of four segments in the third semi-circle (partial explanation indications).

There are two stages involved with opening a package: releasing the lid and dispensing the contents. Consequently, each semi-circle in Figure 9 was repeated on the left and right as

Table 2. Two and three dimensional indications on the selected packaging samples used in the in-depth interviews (continued).

Packaging samples	2D indications	3D indications
 <p>Package 6(b)</p>	 <p>The product name</p>	 <p>The indentations and the ridges</p>
	 <p>The diagrams</p>	 <p>The nozzle</p>
	 <p>The arrow and the plus and minus symbols</p>	 <p>The gap between the lid and the body</p>
	 <p>The written information</p>	 <p>The corresponding marks on the lid and the body</p>

shown in Figure 10 below to represent the two stages of opening. Additionally, different colours are used to differentiate these two stages: white for releasing the lid on the left and black for dispensing the contents on the right.

This visual tool was used to record successful and unsuccessful uses of indications and information for opening the packaging samples evaluated. Through a comparison of the patterns from successful cases, their similarity permitted conclusions to be drawn regarding successful uses of indications and information. Equally, it was possible to draw conclusions on unsuccessful uses of both indications and information.

### Design Recommendations of Combined 2D and 3D Indications to Provide Effective Information for Opening Novel Packaging for Older People

The conclusions about the successful and unsuccessful use of indications and opening information were used to create design recommendations concerning the combined use of 2D and 3D indications as follows:

1. Two and three dimensional indications should be combined when designing a package. The majority of participants used combined 2D and 3D indications to successfully open the packaging samples.

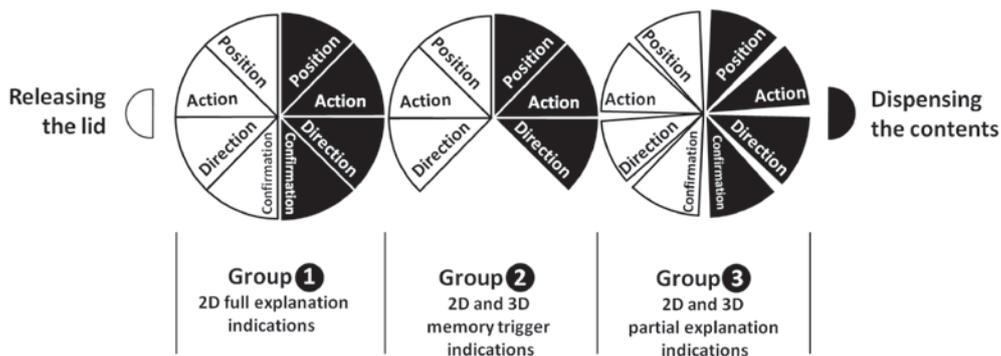


Figure 10: The pattern presenting the use of 2D and 3D indications when releasing the lid and dispensing the contents.

2. When designing memory trigger and partial explanation indications, both 2D and 3D indications should be provided on a package. Participants used different indications to understand how to open the packaging samples. Alternative indications, as well as different indications showing the same information, appeared to help participants to understand how to open the packaging samples, regardless of their varying visual or perceptual impairments.
3. Designers should utilise the three groups of indications: full explanation, memory trigger and partial explanation when communicating how to open packaging. All participants used at least two out of these three groups of indications to effectively understand how to open the packaging samples.
4. Each of the three indications (full explanation, memory trigger and partial explanation) should present three types of information: hand positions, hand actions and hand directions required for opening packaging. All participants used at least two types of information (e.g., hand positions and hand actions) from at least two groups of indications (e.g., full explanation and memory trigger) to understand how to open the packaging samples.
5. Full or partial explanation indications should also be provided for older users to confirm how to open packaging and to confirm successful package opening. Most participants used full or partial explanation indications to confirm how to open the packaging samples and/or whether the packages had been successfully opened.
6. The appearance of unfamiliar packaging does not normally identify potential opening methods. In other words, there are no memory trigger indications. Both full and partial explanation indications should be provided to show the three types of information (hand positions, hand actions and hand directions). Without memory trigger indications, participants relied on full and partial explanation indications. The more information provided, the more easily participants understood how to open the packaging samples.
7. Designers should avoid using ambiguous 3D memory trigger indications that may mislead. In some cases, these familiar indications presented misleading information on how to open the packaging samples. Additional indications are needed to clearly explain how to open the packaging samples.
8. Indications should be easily noticed, identified and read (visibility). Although there were indications on some of the packaging samples, participants did not notice them because of their small size and the low colour contrast between the indications and their background. Accordingly, it was difficult for participants to identify the indications and understand how to open the packaging samples.
9. Use clear language (2D indications) to explain how to open packaging. Ambiguous language misled participants about how to open the packaging sample.

The pattern presenting the use of 2D and 3D indications in Figure 10 above has also the potential to be used as a diagnostic tool by designers to evaluate the understandability of information for opening novel packaging.

## Discussion

Older peoples' design requirements linked to sensory, cognitive and hand decline cannot be isolated because there is a constant interplay between these functions. For hand impairment, the data from the focus groups revealed that a decrease in hand strength significantly limited participants' ability to physically open the packaging samples (Carse et al., 2007). Therefore, shapes (for gripping and holding) as well as methods and mechanisms used for opening packaging have to be carefully considered and tested with older people.

The data from the focus groups showed that impairment of visual acuity and brightness and darkness adaptation negatively affected participants' ability to notice, identify and read indications for opening. Brightness and darkness adaptation (including colour contrast) appears to have a greater impact on older peoples' ability to identify indications than colour perception alone. More attention is needed when designing 2D indications and small 3D indications because their visibility is significantly influenced by colour contrast. Uses of size tended to play a key role in providing 2D indication visibility. Although the data from the focus groups showed that participants mainly relied on information received by seeing, alternative formats (CEN/CENELEC, 2002; Hartson, 2003; Jordan, 1998) of indications received by touch and hearing should be provided so that older people with a wide range of sensory impairment can understand information. Indication visibility is particularly important for older people when packaging appearance is unfamiliar.

The data from the focus groups and the in-depth interviews indicated that unfamiliar packaging samples tended to be more difficult for participants to understand than familiar ones. This supported the data from the literature that ageing impairs both working memory (Craik & Bosman, 1992; Kensinger & Corkin, 2003) and fluid intelligence (Bäckman et al., 2000) when carrying out complex and unfamiliar tasks. The data from the focus groups showed that indications play an important role in helping users understand how to use products (Monö, 1997, Norman, 2002) (e.g., to open novel packaging). Prior knowledge significantly helped participants recognise and understand indications. This confirmed the literature that semantic memory and crystallised intelligence (Bäckman et al., 2000; Stokes, 1992) involving prior knowledge both appear to maintain efficiency with ageing. However, the focus groups and the in-depth interviews revealed that prior knowledge led to participants' misinterpretation of required opening methods due to the absence of clear indications. Additionally, the data from the in-depth interviews showed that participants relied on repeated trial and error attempts before finding out how to open unfamiliar packaging samples when indications were unclear.

Uses of 2D and 3D indications that helped participants to understand how to open the packaging samples in the focus groups were examined further in the in-depth interviews. Three groups of indications were recommended for use when designing novel packaging: full explanation, memory trigger and partial explanation. How to open a package with considerably unfamiliar appearance, in other words one without memory trigger

indications, is more understandable when clear full explanation indications (e.g., diagrams) and familiar partial explanation indications (e.g., an arrow or an indentation) are provided. When unfamiliar opening methods are used due to the employment of novel opening mechanisms, ambiguous memory trigger indications that may mislead should be avoided. Full explanation and familiar partial explanation indications that clearly explain the opening methods should be provided.

The interviews showed that participants used different combinations of 2D and 3D indications to understand how to open the packaging samples. These combined indications were mainly received by seeing and therefore their visibility was crucial. Although only one participant used audible indications (as feedback when releasing a lid), indications received by alternative senses such as hearing should not be neglected when designing a package.

The data from this study were drawn from a small number of participants. Therefore, the findings of this study cannot be generalised to a wider population. However, this study offers an opportunity to gain detailed and rare insights into individual perspectives “to illuminate the general by looking at the particular” (Denscombe, 2007, p.36). The use of 2D and 3D indications, derived from this in-depth examination provides important, new considerations for designers when designing novel packaging for older people.

The data from the focus groups and the in-depth interviews showed that the stereotypical relationship of packaging appearance (indications) to opening methods, played a key role in understanding how to open packaging. It would be useful for future work to establish the stereotypical relationship recognised by different user generations. This would help designers provide understandable opening indications for all.

The quantitative information about health related conditions collected in the focus groups was used to identify possible reasons behind any difficulties that participants had when opening the packaging samples. It would be useful for future work to investigate the impact of age-related decline on opening ability, in particular to see if older people who have visual impairment and/or arthritis overcome opening difficulties differently. This investigation would further help in designing openable packaging for older people.

## Conclusions

Age-related needs in sensory, hand and especially cognitive functions should be taken into account when designing novel packaging to ensure that the packaging is openable by older people. Design attributes for a package fundamentally comprise 2D and 3D elements. However older people may find it difficult to understand how to open packages that have both 2D and 3D indications if these indications are not designed co-jointly to respond to older peoples’ perception and understanding. This study offers design recommendations around the use of combined 2D and 3D indications for designers to consider when designing novel packaging for older people.

## Acknowledgments

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## Endnotes

1. The DTI was replaced by the Department for Business, Enterprise and Regulatory Reform (BERR) in 2007 (the Department for Business, Innovation and Skills (BIS, n.d.). In 2009, the BERR was replaced by the BIS (2009).
2. Age Concern England and Help the Aged joined together in April 2009. They are now known as Age UK (Age UK, 2010).
3. The Thousand Elders is a nationwide panel of older people age 50+ drawn from various socio-economic backgrounds (Nayak, 1998). At the time when the focus groups were conducted, there were around 3,000 members.

## References

1. Abras, C., Maloney-Krichmar, D., & Preece, J. (2004). User-centered design. In W. S. Bainbridge (Ed.), *Berkshire encyclopedia of human-computer interaction* (pp. 763-768). Great Barrington, MA: Berkshire Publishing Group.
2. Age UK. (2010). *Our history*. Retrieved January 1, 2011, from <http://www.ageuk.org.uk/about-us/who-we-are/our-history/>
3. Ah-Chan, J. J., & Downes, S. (2006). The aging eye. *Reviews in Clinical Gerontology*, 16(2), 125-139.
4. Aigner, T., Haag, J., Martin, J., & Buckwalter, J. (2007). Osteoarthritis: Aging of matrix and cells - going for a remedy. *Current Drug Targets*, 8(2), 325-331.
5. Altman, R., Alarcón, G., Appelrouth, D., Bloch, D., Borenstein, D., Brandt, K., ...& Wolfe, F. (1990). The American College of Rheumatology criteria for the classification and reporting of osteoarthritis of the hand. *Arthritis Rheumatism*, 33(11), 1601-1610.
6. Ambrosius, G. R. (2010). Brand matters in an aging marketplace. *The Journal on Active Aging*, May/June, 28-35.
7. Bäckman, L., Small, B. J., Wahlin, A., & Larsson, M. (2000). Cognitive functioning in very old age. In F. I. M. Craik & T. A. Salthouse (Eds.), *The handbook of aging and cognition* (pp. 499-558). Mahwah, NJ: Lawrence Erlbaum Associates.
8. Benjafeld, J. G. (1992). *Cognition*. London: Prentice-Hall International.
9. Berns, T. (1981). The handling of consumer packaging. *Applied Ergonomics*, 12(3), 153-161.
10. Birren, J. E. (1964). *The psychology of aging*. Englewood Cliffs, NJ: Prentice-Hall.

11. Birren, J. E., & Renner, V. J. (1977). Research on the psychology of ageing: Principles and experimentation. In J. E. Birren & K. W. Schaie (Eds.), *Handbook of the psychology of aging* (pp. 3-38). New York: Van Nostrand Reinhold.
12. BIS. (2009). *Simplification plan 2009: Delivering a better business environment*. Retrieved 25 December 2010, from <http://www.berr.gov.uk/files/file53978.pdf>
13. BIS. (n.d.). *The department for business, enterprise and regulatory reform (2007-)*. Retrieved 25 December 2010, from <http://webarchive.nationalarchives.gov.uk/20100216092443/http://www.berr.gov.uk/aboutus/corporate/history/outlines/berr/page49565.html>
14. Bix, L. (2002). The elements of text and message design and their impact on message legibility: A literature review. *Journal of Design Communication*, 4. Retrieved August 21, 2005, from <http://scholar.lib.vt.edu/ejournals/JDC/Spring-2002/bix.html>
15. Blakey, S., Rowson, J., Tomlinson, R. A., Sandham, A., & Yoxall, A. (2009). Squeezability. Part 1: A pressing issue. *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science*, 233(11), 2615-2625.
16. Carmeli, E., Patish, H., & Coleman, R. (2003). The aging hand. *Journal of Gerontology: Medical Sciences*, 58(2), 146-152.
17. Carse, B., Thomson, A., & Stansfield, B. (2007). *Packaging and the older adult*. Retrieved November 25, 2008, from [http://www.ektakta.com/include/files2/54-2\\_54-1173890719.pdf](http://www.ektakta.com/include/files2/54-2_54-1173890719.pdf)
18. Cattell, R. B. (1963). Theory of fluid and crystallized intelligence: A critical experiment. *Journal of Educational Psychology*, 54(1), 1-22.
19. Cayton, A. C. (1995). *Packaging design: Recommendations for providing tactile information*. Unpublished manuscript.
20. CEN/CENELEC. (2002). *CEN/CENELEC guide 6: Guidelines for standards developers to address the needs of older persons and persons with disabilities*. Retrieved June 13, 2007, from [ftp://ftp.cen.eu/BOSS/Reference\\_Documents/Guides/CEN\\_CLC/CEN\\_CLC\\_6.pdf](ftp://ftp.cen.eu/BOSS/Reference_Documents/Guides/CEN_CLC/CEN_CLC_6.pdf)
21. Chivers, J. (2003). Care of older people with visual impairment. *Nursing Older People*, 15(1), 22-26.
22. Clarke, J. I. (1993). The demography of ageing in Europe. In P. R. Kaim-Caudle, J. Keithley, & A. Mullender (Eds.), *Aspects of ageing* (pp. 71-80). London: Whiting & Birch.
23. Cole, C. A., & Balasubramanian, S. K. (1993). Age differences in consumers' search for information: Public policy implications. *Journal of Consumer Research*, 20(1), 157-169.
24. Coleman, R. (1996). *How will the older people consumers want to shop in the future?* Unpublished manuscript.
25. Craik, F. I. M., & Bosman, E. A. (1992). Age-related changes in memory and learning. In H. Bouma & J. A. M. Graafmans (Eds.), *Gerontechnology* (pp. 79-92). Amsterdam, Netherlands: IOS Press.
26. Cunningham, W. R., & Brookback, J. W. (1988). *Gerontology: The psychology, biology and sociology of aging*. New York: Happer and Row.
27. Daley, M. J., & Spinks, W. L. (2000). Exercise, mobility and aging. *Sports Medicine*, 29(1), 1-12.
28. de la Fuente, J., & Bix, L. (2005). *Applying universal design to child-resistant packaging*. Retrieved December 11, 2005, from <http://www.hhc.rca.ac.uk/archive/hhrc/programmes/include/2005/proceedings/pdf/delafuentejavier.pdf>
29. Denscombe, M. (2007). *The good research guide for small-scale social research projects* (3rd ed.). Maidenhead, UK: Open University Press.
30. DTI. (1999). *Government consumer safety research: How to improve safe packaging disposal instructions*. London: Department of Trade and Industry.
31. Duizer, L. M., Robertson, T., & Han, J. (2009). Requirements for packaging from an ageing consumer's perspective. *Packaging Technology and Science*, 22(4), 187-197.
32. Dunnell, K. (2007). The changing demographic picture of the UK national statistician's annual article on the population. *Population Trends*, 130(Winter), 9-21.
33. Estes, J. P., Bochenek, C., & Fassler, P. (2000). Osteoarthritis of the fingers. *Journal of Hand Therapy*, 13(2), 108-123.
34. Fiske, M. (1980). Tasks and crises of the second half of life: The interrelationships of commitment, coping and adaptation. In J. E. Birren & R. B. Sloane (Eds.), *Handbook of mental health and aging* (pp. 337-376). London: Prentice-Hall.
35. Galley, M., Elton, E., & Haines, V. (2005, October). *Packaging: A box of delights or a can of worms? The contribution of ergonomics to the usability, safety and semantics of packaging*. Paper presented at the FaraPack Briefing 2005: New Technologies for Innovative Packaging, Loughborough, UK.
36. Gana, K., Alaphilippe, D., & Bailly, N. (2004). Positive illusions and mental and physical health in later life. *Ageing & Mental Health*, 8(1), 58-64.
37. Gates, G. A., & Mills, J. H. (2005). Presbycusis. *The Lancet*, 366(9491), 1111-1120.
38. Goldstein, E. B. (1980). *Sensation and perception*. Belmont, CA: Wadsworth.
39. Hartson, H. R. (2003). Cognitive, physical, sensory, and functional affordances in interaction design. *Behaviour & Information Technology*, 22(5), 315-338.
40. Iivari, N. (2004). Enculturation of user involvement in software development organizations: An interpretive case study in the product development context. In *Proceedings of the 3rd Nordic Conference on Human-Computer Interaction*, (pp. 287-296). New York: ACM.
41. Janson, R., Yoxall, A., & Hayes, S. (2005). *Human ability and openability: Producing design limits for consumer packaging*. Retrieved December 11, 2005, from <http://www.hhrc.rca.ac.uk/programmes/include/2005/proceedings/pdf/jansonr.pdf>

42. Jordan, P. W. (1998). *An introduction to usability*. London: Taylor & Francis.
43. Kart, C. S., Metress, E. S., & Metress, J. (1978). *Aging and health: Biologic and social perspectives*. London: Addison-Wesley.
44. Keates, S., & Clarkson, J. (2003). *Countering design exclusion: An introduction to inclusive design*. London: Springer-Verlag.
45. Kensinger, E. A., & Corkin, S. (2003). Neural changes in aging. In L. Nadel (Ed.), *Encyclopedia of cognitive science* (pp. 70-78). London: Nature Publishing Group.
46. Leventhal, R. C. (1997). Aging consumers and their effects on the marketplace. *Journal of Consumer Marketing*, 14(4), 276-281.
47. Lewis, R., Menardi, C., Yoxall, A., & Langley, J. (2007). Finger friction: Grip and opening packaging. *Wear*, 263(7-12), 1124-1132.
48. Mawle, R. (2003). *Which pill when: Packaging that aids compliance in taking medication*. Retrieved August 30, 2006, from <http://www.hhc.rca.ac.uk/archive/hhrc/programmes/ra/2003/miche.html>
49. Metz, D. H. (2000). Mobility of older people and their quality of life. *Transport Policy*, 7(2), 149-152.
50. Minkler, M. (1994). Aging and disability: Behind and beyond the stereotypes. In R. B. Enright, Jr. (Ed.), *Perspectives in social gerontology* (pp. 11-21). London: Allyn and Bacon.
51. Monö, R. (1997). *Design for product understanding: The aesthetics of design from a semiotic approach*. Stockholm, Sweden: Liber.
52. Moore, E. J. (1993). *Grocery packaging openability: Recommendations for immediate improvements*. Watford, UK: Institute of Grocery Distribution.
53. Moore, E. J. (1995). *Grocery packaging openability: An open or shut case?* Watford, UK: Institute of Grocery Distribution.
54. Moore, E. J., & Nayak, U. S. L. (1992). *Grocery packaging openability and the elderly consumer*. Watford, UK: Institute of Grocery Distribution.
55. Nayak, U. S. L. (1998). Design participation by the Thousand Elders. In J. Graafmans, V. Taipale, & N. Charness (Eds.), *Gerontechnology: A sustainable investment in the future* (pp. 423-427). Amsterdam: IOS Press.
56. Neugarten, B. L. (1974). Age groups in American society and the rise of the young-old. *The ANNALS of the American Academy of Political and Social Science*, 415(1), 187-198.
57. Norman, D. A. (1999). Affordances, conventions, and design. *Interactions*, 6(3), 38-42.
58. Norman, D. A. (2002). *The design of everyday things*. New York: Basic Books.
59. Onkvisit, S., & Shaw, J. J. (1989). *Product life cycles and product management*. London: Quorum Books.
60. ONS. (2005). *Focus on older people*. Retrieved September 13, 2009, from [http://www.statistics.gov.uk/downloads/theme\\_compendia/foop05/Olderpeople2005.pdf](http://www.statistics.gov.uk/downloads/theme_compendia/foop05/Olderpeople2005.pdf)
61. ONS. (2008). *Family spending: A report on the 2007 expenditure and food survey*. Basingstoke, UK: Palgrave Macmillan.
62. Oostendorp, J. A., Bode, J. M., Lutters, E., & Van Houten, F. J. A. M. (2006). *The (development) life cycle for packaging and the relation to product design*. Paper presented at the 13th CIRP International Conference on Life Cycle Engineering (pp. 207-212). Belgium: Katholieke Universiteit Leuven.
63. Parsons, M. A., & Felton, G. (1990). Young and middle adulthood: The working years. In B. Bullough & V. Bullough (Eds.), *Nursing in the community* (pp. 404-437). St. Louis, MO: Mosby.
64. Pirkkl, J. J. (1994). *Transgenerational design: Products for an aging population*. New York: Van Nostrand Reinhold.
65. Reginster, J. Y. (2002). The prevalence and burden of arthritis. *Rheumatology*, 41(suppl 1), 3-6.
66. Schiffman, L. G., & Sherman, E. (1991). Value orientations of new-age elderly: The coming of an ageless market. *Journal of Business Research*, 22(2), 187-194.
67. Schonfield, D. (1980). Learning, memory and aging. In J. E. Birren & R. B. Sloane (Eds.), *Handbook of mental health and aging* (pp. 214-244). London: Prentice-Hall.
68. Simpson, J. A., & Weiner, E. S. C. (1989). *Oxford English dictionary* (2nd ed.). Oxford: Oxford University Press.
69. Smith, S., Norris, B., & Peebles, L. (2000). *Older adultdata: The handbook of measurements and capabilities of the older adult: Data for design safety*. London: Department of Trade and Industry.
70. Smyth, M. M., Collins, A. F., Morris, P. E., & Levy, P. (1994). *Cognition in action*. East Sussex, UK: Lawrence Erlbaum Associates.
71. Stokes, G. (1992). *On being old: The psychology of later life*. London: Falmer Press.
72. Stroud, D. (2005). *The 50-plus market: Why the future is age neutral when it comes to marketing & branding strategies*. London: Kogan Page.
73. Stuart-Hamilton, I. (2000). *The psychology of ageing: An introduction* (3rd ed.). London: Jessica Kingsley.
74. Symmons, D., Turner, G., Webb, R., Asten, P., Barrett, E., Lunt, M., ...& Silman, A. (2002). The prevalence of rheumatoid arthritis in the United Kingdom: New estimates for a new century. *Rheumatology*, 41(7), 793-800.
75. Thompson, C., & West, P. (1984). The public appeal of sheltered housing. *Ageing and Society*, 4(3), 305-326.
76. Thompson, N. J., & Thompson, K. E. (2009). Can marketing practice keep up with Europe's ageing population? *European Journal of Marketing*, 43(11/12), 1281-1288.
77. Tinker, A. (1997). *Older people in modern society* (4th ed.). Harlow, UK: Longman.
78. Tomassini, C. (2005). The demographic characteristics of the oldest old in the United Kingdom. *Population Trends*, 120(summer), 15-22.
79. Victor, C. R. (2005). *The social context of ageing*. London: Routledge.

80. Watkinson, S. (2005). Visual impairment in older people: The nurse's role. *Nursing Standard*, 19(17), 45-52.
81. Welford, A. T. (1980). Sensory, perceptual, and motor processes in older adults. In J. E. Birren & R. B. Sloane (Eds.), *Handbook of mental health and aging* (pp. 192-213). London: Prentice-Hall.
82. Whitbourne, S. K. (2001). *Adult development & aging: Biopsychosocial perspectives*. Chichester, UK: John Wiley.
83. White, K. (1993). How the mind ages. *Psychology Today*, 26(6), 38-42.
84. WHO. (2002). *Active ageing: A policy framework*. Retrieved March 22, 2005, from [http://whqlibdoc.who.int/hq/2002/WHO\\_NMH\\_NPH\\_02.8.pdf](http://whqlibdoc.who.int/hq/2002/WHO_NMH_NPH_02.8.pdf)
85. Wilkes, R. E. (1992). A structural modeling approach to the measurement and meaning of cognitive age. *Journal of Consumer Research*, 19(2), 292-301.
86. Winder, B. (2006). The design of packaging closures. In N. Theobald & B. Winder (Eds.), *Packaging closures and sealing systems* (pp. 36-67). Oxford: Blackwell Publishing.
87. Winder, B., Ridgway, K., Nelson, A., & Baldwin, J. (2002). Food and drink packaging: Who is complaining and who should be complaining. *Applied Ergonomics*, 33(5), 433-438.
88. Windmill, V. (1990). *Ageing today: A positive approach to caring for elderly people*. London: Edward Arnold.
89. Woodcock, A., Torrens, G., & McDonagh, D. (2004). Emotional response to food packaging. In D. McDonagh, P. Hekkert, J. van Erp, & D. Gyi (Eds.), *Design and emotion: The experience of everyday things* (pp. 308-313). London: Taylor & Francis.
90. Yoxall, A., Kamat, S. R., Langley, J., & Rowson, J. (2010). Squeezability. Part 2: Getting stuff out of a bottle. In *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science*, 224(6), 1261-1271.