RTD

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Method& Critique *Frictions and Shifts in RTD*

Connected Resources: A Research Through Design Approach to Designing for Older People's Resourcefulness

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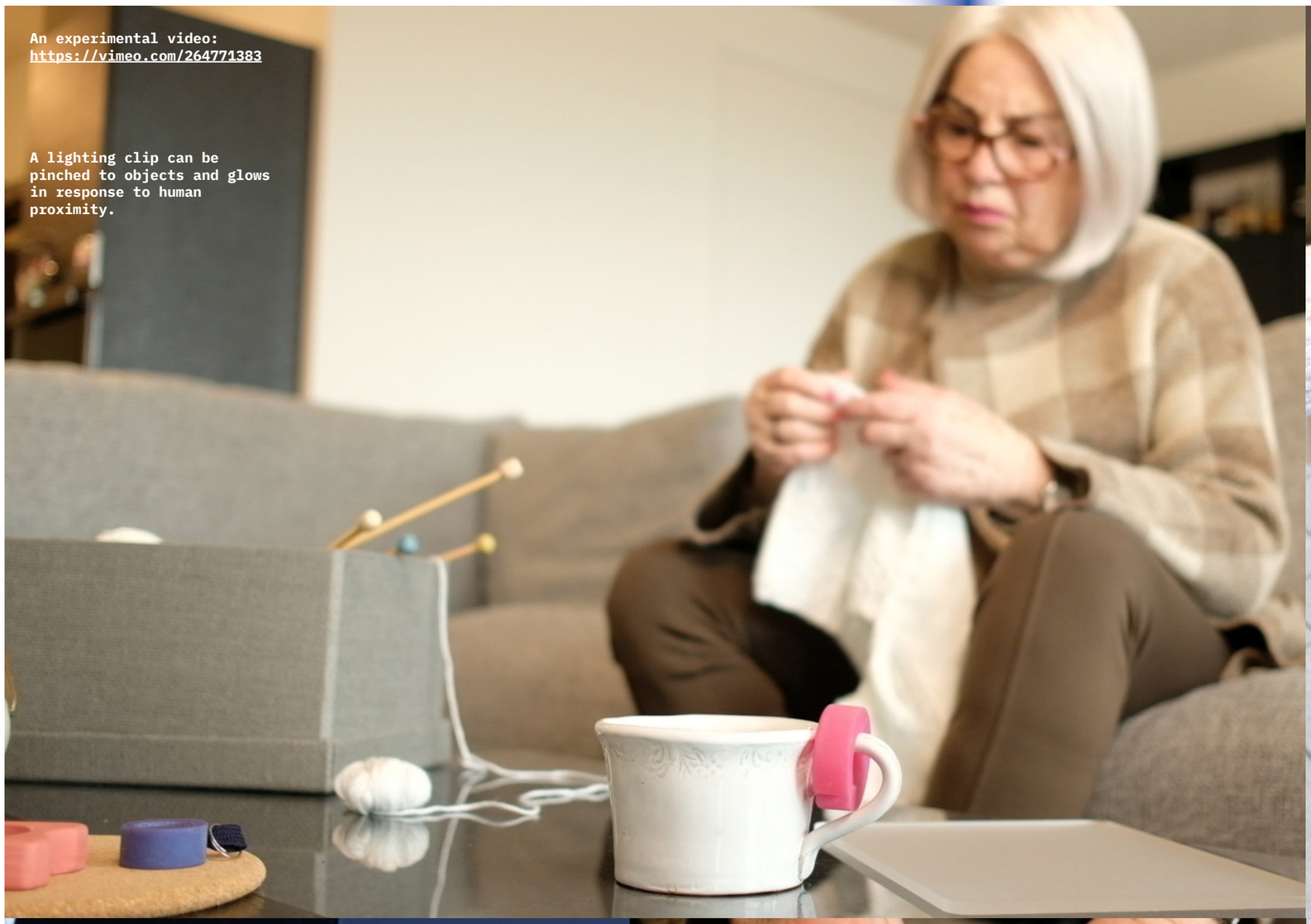
Abstract: Connected Resources are a family of combinable devices that add digital capabilities to mundane objects, in order to support everyday strategies of resourcefulness in older people. Using Connected Resources as an example, this paper describes designing for older people's resourcefulness using an RtD process. Here, the artifact dimensions of openness, which is needed when designing for resourcefulness, are generated through an experimental study with prototypes. The dimensions of a variety of use were identified during a participatory session in which uses for prototypes in the everyday practices of older people were explored. Finally, design considerations to ensure older people's different levels of independence from technology were determined. The paper first describes three working prototypes built during the first design iteration. It then moves on to showcase two studies conducted with these prototypes and the insights in relation to the variables of openness and variety. Finally, we discuss how these insights were used to redefine functionalities and interaction qualities in the second iteration, and how these insights influenced the prototypes' shape, materiality and semiotics, as well as the conceptualization of data visualizations on the online platform. Lastly, we provide a reflection of the knowledge generated in the RtD process.

Keywords: Smart Objects; IoT; Connected Everyday; Gerontechnology; Research through Design

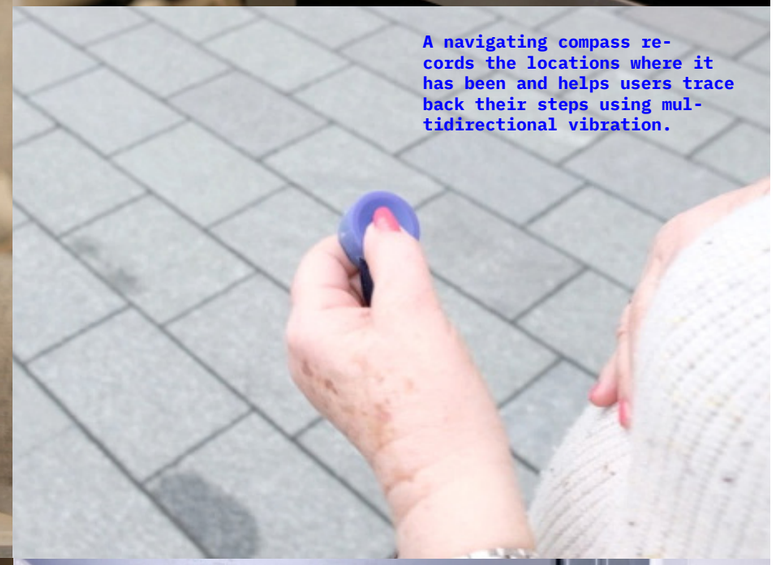
Method& Critique



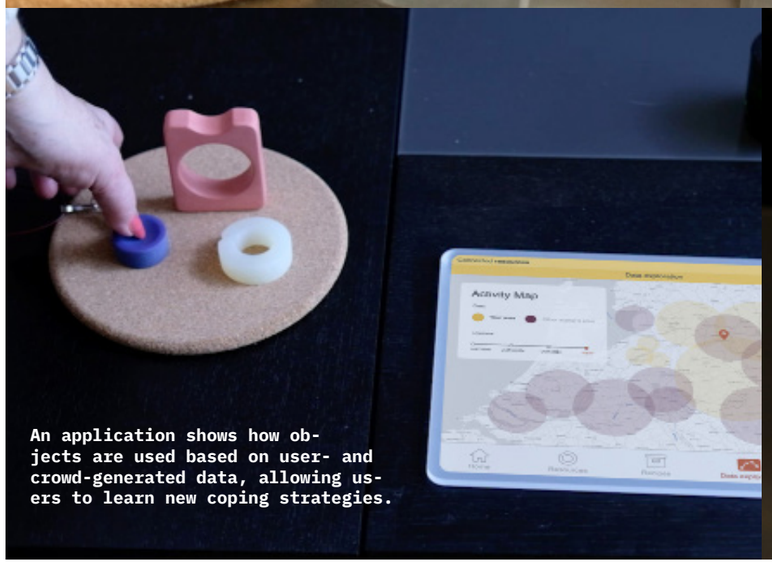
An experimental video:
https://vimeo.com/264771383

A lighting clip can be pinched to objects and glows in response to human proximity.

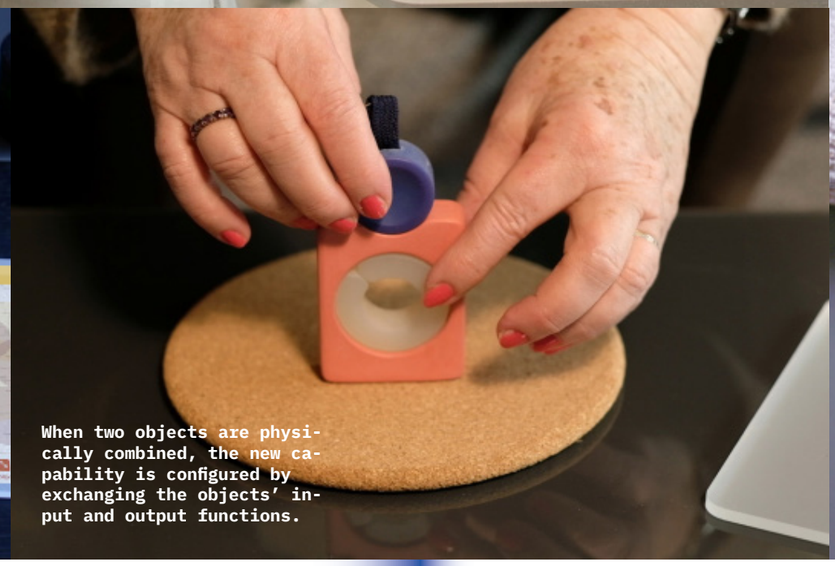
A linking frame allows users to keep digital pictures and videos together, accessed by a phone or tablet placed close to it.



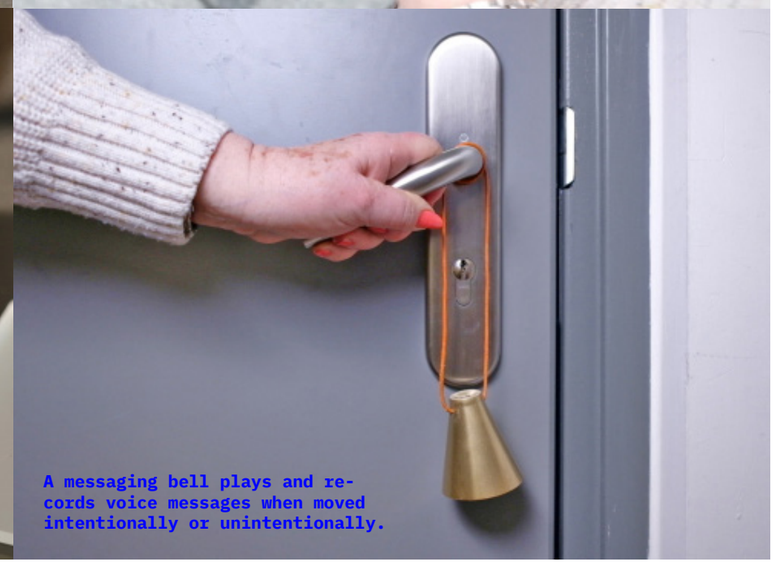
A navigating compass records the locations where it has been and helps users trace back their steps using multidirectional vibration.



An application shows how objects are used based on user- and crowd-generated data, allowing users to learn new coping strategies.



When two objects are physically combined, the new capability is configured by exchanging the objects' input and output functions.



A messaging bell plays and records voice messages when moved intentionally or unintentionally.

1. Introduction

Designing technology for older people to support existing capabilities of resourcefulness

The demographic trend of ageing society has spurred designers and developers to provide older people with smart-connected products that support vital and valuable activities in homes (Nicenboim, Giaccardi & Kuijer 2018; Soro, Ambe & Brereton 2017; Vaisutis et al. 2014). However, these so-called gerontechnologies tend to be created based on single-use scenarios that are narrowly predefined based on stereotypes of older people as passive, immobile and technologically incompetent. Failing to address the variety of situations older people experience, these smart products may limit such individuals' meaningful activities and autonomy, as well as create economic losses (Hyysalo 2006; Neven 2010).

To address this issue, a project Resourceful Aging started by bringing together designers, computer scientists, social scientists and professional practitioners from Delft University of Technology, Eindhoven University of Technology, Avans University of Applied Sciences and Philips Design with the goal of researching and designing an internet of things (IoT) solution that empowers older people to age resourcefully. Stepping away from stereotypes of older people and instead viewing them as capable of overcoming daily challenges (Giaccardi, Kuijer & Neven 2016), Connected Resources was created, forming a set of connected objects that can be adapted and improvised during use. This generated value in a wide variety of situations and allowed the design to encourage resilience and independence among older people during their day-to-day lives.

In this article, we discuss how Connected Resources was designed and what knowledge was gained during the research through design (RtD) process. First, the initial iteration of designing Connected Resources, which was inspired by an ethnographic study of older people at home, is presented. Then, two studies using the first prototypes of Connected Resources are described, one of which conducted to understand the artefactual dimensions and to form guidelines for artefacts as resources. The other was a participatory session with older people participants that illuminated a variety of uses for the devices and further insight into the meaning of independence. It is subsequently shown that the second design iteration of Connected Resources offers a high degree of freedom of use for a set of combinable physical objects and an online platform. The article closes by summarising the knowledge gained during the RtD process for resourcefulness as it pertained to openness, variety and the meaning of independence among older people.

2. RtD approach to designing for resourcefulness

Activities using prototypes as research artefacts installed to elicit knowledge

Being resourceful is about using artefacts, technologies and other people as resources to solve challenges arising from nonstandard situations. It is relatively understudied and particularly challenging to capture because it occurs spontaneously in everyday situations and can involve uses of resources that deviate from normative uses which may be socially sensitive to share (Kuijer, Giaccardi & Nicenboim 2017). As such, resourcefulness links to improvisation that emerges from a situated way where people and artefact work together (Kuijer et al. 2017).

To understand resourcefulness and ageing, an RtD approach was used by integrating prototypes as research materials in a creative cycle (Stappers & Giaccardi 2017). Since a prototype can offer a way to experience a future situation, RtD was suitable for exploring the phenomenon of resourcefulness which requires exploration in a situated way. It also offered reflection on guidelines for designing for resourcefulness through evaluating how people actually interact with prototypes in a realistic context (Gaver 2012).

The project consisted of two iterations (Figure 1). In the first iteration, the working prototypes of Connected Resources were designed (Nicenboim, Giaccardi & Kuijer 2018; Nicenboim & Kitazaki et al. 2018), inspired by knowledge gained from an extended ethnographic engagement with five participants in the age range of 65 and 78. By making use of the first prototypes, two experimental studies were conducted in the second iteration, based on knowledge obtained from which the second model of Connected Resources was created. The field research and creation of the first iteration are discussed Nicenboim, Giaccardi & Kuijer (2018) and Nicenboim & Kitazaki et al. (2018). Below, we summarise their main conclusions and further focus on the second iteration.

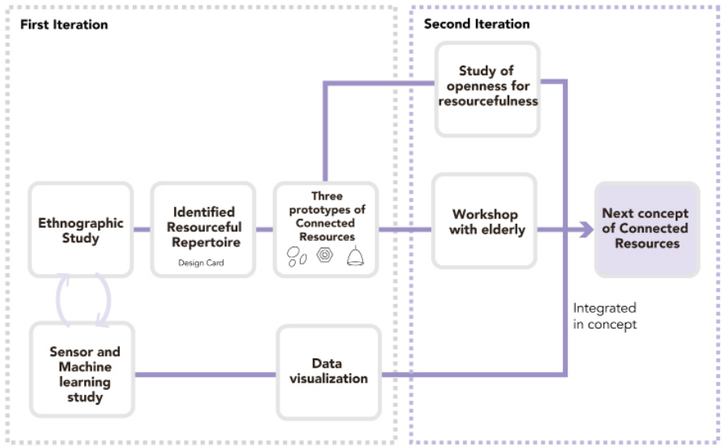


Figure 1. Two iterations and all the activities of the project

3. First iteration of Connected Resources

An ethnographic study that revealed the resourcefulness of older people was used to create the first prototypes of Connected Resources.

The first iteration began with an ethnographic study to understand five older people's (age from 65 to 78) resourceful practices. This study used a thing-centred approach (Giaccardi & Cila et al. 2016), and through one-week assignments and interviews with walkthroughs in their homes, the participants' valuable activities and resourceful practices were captured. For example, one participant who loved hand sewing kept a magnetic iron bolt in her sewing box since she repurposed it as a thin-needle-picker because her rheumatoid arthritis made it difficult to do this with her fingers. Another participant used the sharing of a newspaper to communicate her well-being to her daughter in an unobtrusive way by bringing it to her daughter's home every afternoon (Nicenboim, Giaccardi, and Kuijer, 2018).

To analyse the ethnographic data, we clustered photos taken in the study into three categories: (1) resources: physical materials and everyday objects which tended to be used in resourceful ways such as magnets and bands; (2) capabilities: abilities that resources presented such as hanging, inserting, and wrapping; and (3) strategies: know-hows or emergent systems which older people developed over time such as bodily extensions, sharing for communication. We then translated the clusters into ideation cards and added (4) digital capabilities (e.g. navigating and showing status, for making it connected technologies) as a new category, because it was our aim to make these digital capabilities available to our target group as resources.

The card set was used in a design workshop to ideate connected resources that can be used in a variety of ways in older people's lives. We did this by picking one card from each category and generated ideas inspired by their combination, After several rounds, we chose three ideas and worked them out into working prototypes (Nicenboim, Giaccardi & Kuijer 2018; Nicenboim & Kitazaki et al. 2018).

One was Connected Stones, which guided sequences of actions by glowing one by one, like leaving a trail of crumbs. Another was Connected Magnets, which used embedded near-field communication tag storing of digital content. This allowed participants to arrange the objects around various practices to access related content in a situated way. The third was Connected Bells which had a phone number and played a recorded voice message through a phone when moved. These allowed users to create triggers in various places along their everyday pathways. These high-fidelity prototypes allowed the participants to imagine possible new futures (Dunne & Raby 2013) and allowed the researchers to further gain knowledge to design devices for resourcefulness among older people.

Figure 2. Three prototypes created in the first iteration

4. The openness and resourcefulness of the first prototypes

Dimensions of openness to encourage various adaptations and dimensions of closedness to promote simplicity and familiarity of artefacts.

The first study using the prototypes was conducted to understand their openness, which is a crucial product feature that allows a device to be adapted as a resource to overcome daily challenges in changing situations (Botero, Kommonen & Marttila 2010; Wakkary & Maestri 2008). Since openness is a broad and abstract concept, here, it needed to be understood in relation to resourcefulness. Thus, a literature review and content analysis were conducted on topics of appropriation, design-in-use, everyday design, meta-design, and open design, which identified ten dimensions of openness. Each dimension had two extreme poles: one open and one closed to evaluate openness as well as closedness. For example, the dimension of structure, which is about the functional mechanisms of how an artefact works, is simple (i.e., closed) and complex (i.e., open). This was because we had identified in the previous studies that certain dimensions should be open to make an artefact suitable across different practices and others that should be closed to make it familiar and easy to use (Nicenboim, Giaccardi & Kuijer 2018). In order to know what extent openness or closedness of each dimension contributes to resourcefulness, an experimental study was conducted using three prototypes.

Experimental study

In addition to the three prototypes, a set of artefacts from three different categories was selected (Figure 3). Participants were design students who were comfortable associating designs with words. First, they evaluated whether they could use the artefacts as resources that could be adapted to various purposes and spontaneous situations. Interviews were conducted to understand the rationale behind their judgments. Second, they evaluated which level these resources were positioned between open and closed on each dimension. Last, they were asked how the evaluated levels between the two extremes contributed to resourcefulness to explore participants' thoughts on the impact that openness or closedness had on resourcefulness. The participants interacted with the actual artefacts while evaluating them so that they could imagine everyday situations and uses.

Figure 3. Twelve artefacts from three different categories that were used in the study

Results

The results revealed that the artefacts that contributed to resourcefulness were Connected Magnets, rope, a Bluetooth tracker and Connected Bells. In contrast, IFTTT, Wiki, email and Connected Stones were not regarded as resources, since participants thought these artefacts could be adapted for various purposes but not for spontaneous situations because of their complicated operational procedures. Other artefacts, such as remote controls, coffee machines and kitchen cabinets, were not perceived as resources at all. Figure 5 (next page)shows the results of the evaluation; each point (from -5 for closed to 5 for open) shows the average of four artefacts regarded as resources, which was averaged from the evaluations of ten participants.

The results also allowed for a comparison of the three prototypes evaluated (Figure 6). The results showed that Connected Magnets were evaluated as the most resources because of their highest simplicity, expandability, familiarity and dedicated features, and participants were comfortable using Connected Magnets in resourceful ways. Connected Bells were also perceived as resources, but not as much as Connected Magnets, due to their clear signifiers and simplicity, expandability and familiarity for adaptation. Connected Stones were not considered resources because of their complexity, their ambiguous signifier and their novelty, which prevented their adaptation fit in various situations.

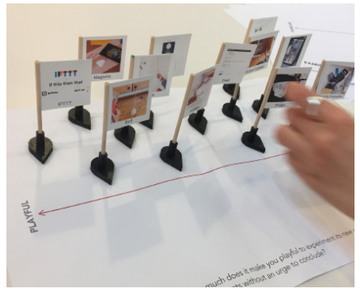


Figure 4. Participants evaluated where the artefacts were positioned between two extremes of openness and closedness for each dimension

Knowledge gained by RtD: Dimensions of openness for resourcefulness

The study concluded that the five dimensions should be open and the other five should be closed so that people perceive an artefact as a resource. We detail the results with comments of the participants.

As for five open dimensions, the dimension of interface, which enables an artefact to connect other products or systems, is required to open for expanding its capabilities. Some participants mentioned organic assemblage by expandable interfaces allowed them to tailor artefacts to their practices. The dimension of self-adaptation, which refers to varying levels of structural changes (Botero, Kommonen

Figure 5(left). The average positions of the artefacts that could be used as resources (i.e., Connected Magnets, rope, Bluetooth tracker and Connected Bells) on each dimension

Figure 6(right). Comparison of the positions of three prototypes on each dimension

& Marttila 2010), should be open since it affected the dynamism of changes. For example, Connected Magnets were perceived as more resource than Connected Stones since they could be changed on various levels such as content and places to be attached, while Connected Stones can only be changed in terms of where they are placed. However, since Wiki and IFTTT were not regarded as resources despite offering various levels of self-adaptations because of their complexity, the balance to simplicity is necessary. The dimension of knowledge should be learnable and delivered through instructions or open knowledge-sharing communities (Abel et al. 2011; Botero, Kommonen & Marttila 2010; Fischer & Giaccardi 2006), since the participants appreciated the use instructions for the Bluetooth tracker and the online platform that allowed participants to share IFTTT 'recipes'. The quality of the learning should be playful, allowing users to explore through trial and error (Fischer & Giaccardi 2006). Since some participants mentioned that artefacts that were "physically tinkerable" increased playfulness, learning should involve physical interactions with artefacts. Finally, a mindset towards newness helped participants explore the prototypes in new ways without fear of breaking them, and such "fear [was] overcome by learnability and familiarity".

As for closed dimensions, the dimension of structure should be closed because simplicity led to "an explicit image [of] how the artefact works", allowing participants to readily conceive of alternative product uses. The dimension of content, which refers to types of content that an artefact deals with, may be closed since it was correlated with simplicity of structure and dedicated features. One of the participants expressed that the Bluetooth tracker was like a "raw material" because it only provided location data, which was perceived as a resource. Features should be dedicated rather than multifunctional (Brandes, Stich & Wender 2009), and participants believed that one core function contributed to simplicity. A signifier needs to be closed, while literature indicated that openness of a signifier, ambiguity, allowed for multiple interpretations and adaptations (Gaver, Beaver & Benford 2003; Sengers & Gaver 2006). In the study, participants felt that some levels of an explicit signifier, like Connected Bells, allowed them to quickly identify object capabilities and to create "mental space to conceive alternate uses". Thus, an adequate signifier on an object could allow participants to identify it, providing an entry point to explore personal adaptations. The last dimension of experience needs to be closed since familiar objects with "a long history of use give you enough knowledge of material characteristics", which encouraged participants to develop resourceful uses.

5. Deriving a variety of uses from prototypes

Dimensions of variety of use from use scenarios for the prototypes developed by older people participants

Since resourcefulness occurs across different practices as a dispersed practice (Kuijer, Giaccardi & Nicenboim 2017), artefacts that inspire resourcefulness should be designed for a variety of situations, lifestyles and people instead of being designed to be foolproof in a single scenario (Hyysalo 2006). To understand potential variety, a participatory session was conducted, in which participants (four older people, aged 65–78) discussed how they would configure the three prototypes of the Connected Resources in their everyday practices. Based on their input, the range of use for the prototypes was expanded.

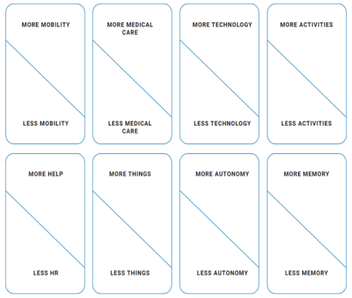


Figure 8. Examples of future cards

Figure 7a, b, c.
a.Participants using cards and a format for mapping cards. The set of cards consisted of objects, tools, materials and persons used in a valued activity.
b.c.The shots of the workshop

Participatory workshop

The three working prototypes were introduced to the participants who were asked to interact with and familiarise themselves with each device. Each participant chose one activity that they valued, and using cards and a format for mapping, participants were encouraged to talk about objects, tools, materials and persons that were involved in these practices (Figure 7a). This brainstorming activity allowed participants to easily think about possible reconfigurations of their current practices using new materials (Lindsay et al. 2012). Once participants came up with ideas of use, design students sketched these ideas. They were assured that there was no correct idea, which allowed participants to use their imaginations to formulate ideas about how to use the prototypes in their valued activities. Then, participants were encouraged to use future cards on which two opposite future situations were illustrated (Figure 8). This prompted researchers and participants to freely think about possible uses for the prototypes in these future situations without sticking with stereotype images of future situations of older people, such as more lonely and less mobile. The generated scenarios were then shared.

The participants developed several use scenarios that were not intended by the designers and researchers when the first prototypes were created. For example, one participant suggested placing the Connected Stones along a path they regularly walked as markers to follow when going home. She applied her knowledge developed through her experiences; she used to walk in mountains and put piled stones on a trail for the same purpose. Another participant wanted the use one Connected Stone as a reminder for her to look at her calendar for birthdays, to remind her that 'someone's birthday is coming'. Another participant imagined using the Connected Magnet to link images of knitting patterns she had collected to share with her daughter and grandchild. She collected them on her tablet and thought that sharing this content through the Connected Magnet, which is a physical object, would be more comfortable than doing so digitally.

Knowledge gained by RtD: Dimensions of variety

From participants imagined use scenarios, six dimensions of variety were identified. One was indoor and outdoor use, such as using Connected Stones or Connected Magnets as markers during walks to find a way back home. Another dimension was user- and crowd-generated content, such as using Connected Magnets to collect images of knitting patterns from the Internet or using Connected Bells to share knowledge of routes in a forest with anonymous peers. The dimension of personal and shared use was suggested in the use of Connected Magnets for sharing images or agendas among family members or using Connected Bells for sharing information with other mountain hikers. The single or multiple resource dimension was identified in the ideas that Connected Stones could remind a person of something or multiple Connected Bells and Connected Stones could be used while hiking in a forest. Another idea was to combine Connected Stones with Connected Magnets to present a map on your smartphone when closing it to a glowing Connected Stone while walking as a route tracker. Finally, fixed-place to mobile-space use was derived from one participant's idea to use a Connected Bell in a car to indicate voice messages from family members while driving. All of these dimensions informed prototype design at both the concept and property levels in the second iteration.

Knowledge gained by RtD: Different levels of technological independence

Older people want to continue their valued activities independently with an appropriate level of help from technology. For example, one participant wanted to use Connected Stones while walking to keep track of direction, rather than following a phone GPS or map; another person wanted Connected Resources to trigger her to remember birthdays. This input implies that older people seek appropriate levels of technological intervention, which can change because resourcefulness occurs in 'everyday crises of routines' (Kuijer, Giaccardi & Nicenboim 2017; Reckwitz 2002) induced in part by ongoing changes of body, mind and environment. Thus, intelligent technology and people should perform practices next to each other, continuously negotiating levels of intervention (Giaccardi, Kuijer & Neven 2016; Kuijer & Giaccardi 2018). In this light, we decided to include an interface from which users can adjust the boundaries of help to adjust their level of independence and autonomy in performing activities.

6. Second iteration of Connected Resoruces

The redesigned Connected Resources provides a high degree of freedom

The first iteration of Connected Resources was redesigned based on the results from the two studies and the resourceful strategies found in the first iteration. We also incorporated the patterns of use of some objects which were found from collected data of jointly selected objects in older people's home by machine learning in the first iteration. Those studies affected the prototype functionality, qualities of interaction and design properties.

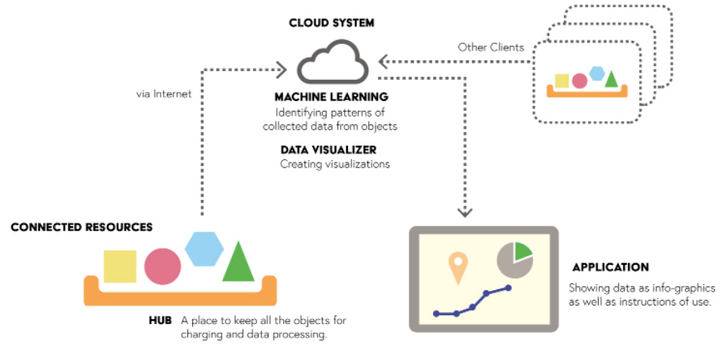


Figure 9. All system configurations for Connected Resources

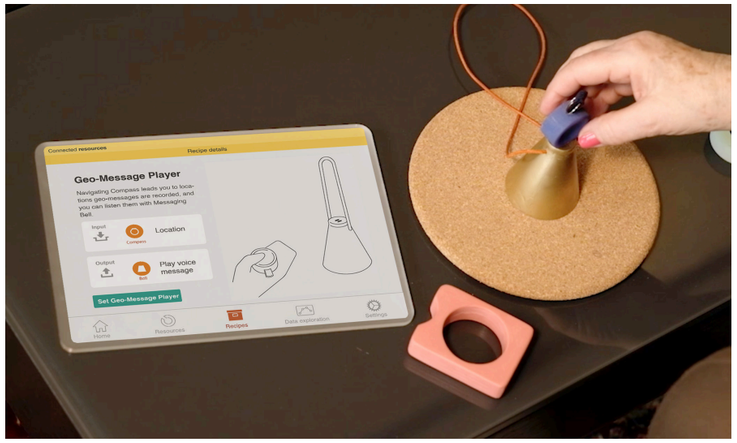


Figure 10(up). When a user puts an object (or combination of objects) on the hub (i.e., the round dish), the application shows information based on the extent of use of the object by the user. For example, if the user uses an object for the first time or is not familiar with it, the application introduces its functionalities and shows examples for object configuration.

Figure 11(bottom). Example user interface for the application, showing the pattern of uses for messaging Connected Bells. The buttons in the upper right lead to user- and crowd-generated patterns of use.

Online platform

An online platform would use machine learning to recognise and visualise patterns of use for sharing among users. (Figure 9). Such a platform allows users to learn creative uses for Connected Resources and would encourage exploration and personal adaptation of the devices. The application also provides configurations for devices to guide users to adapt them to their practices (Figure 10). A hub is used to charge objects based on the ethnographic study participants' practices to group relevant everyday tools and things together in their room. When a user puts an object on the hub, the application shows a screen of data visualisations about the use of the object, from which the user learns his or her own uses and compares them to those of others (Figure 11). The screen also shows a link to instructions to set up objects, which triggers the user to adjust object capabilities to find the best level of intervention for them.

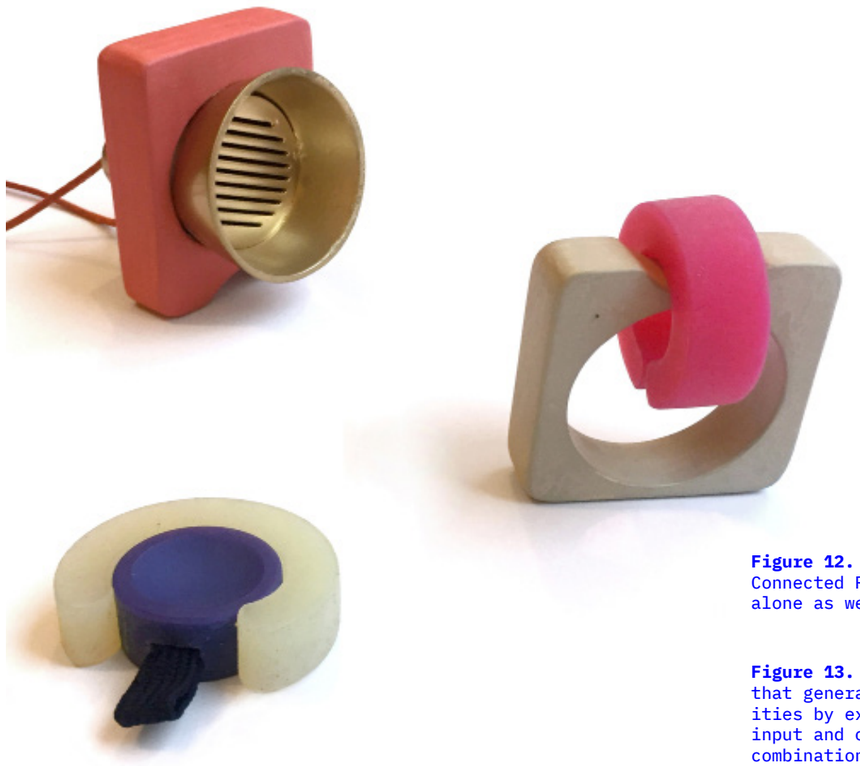
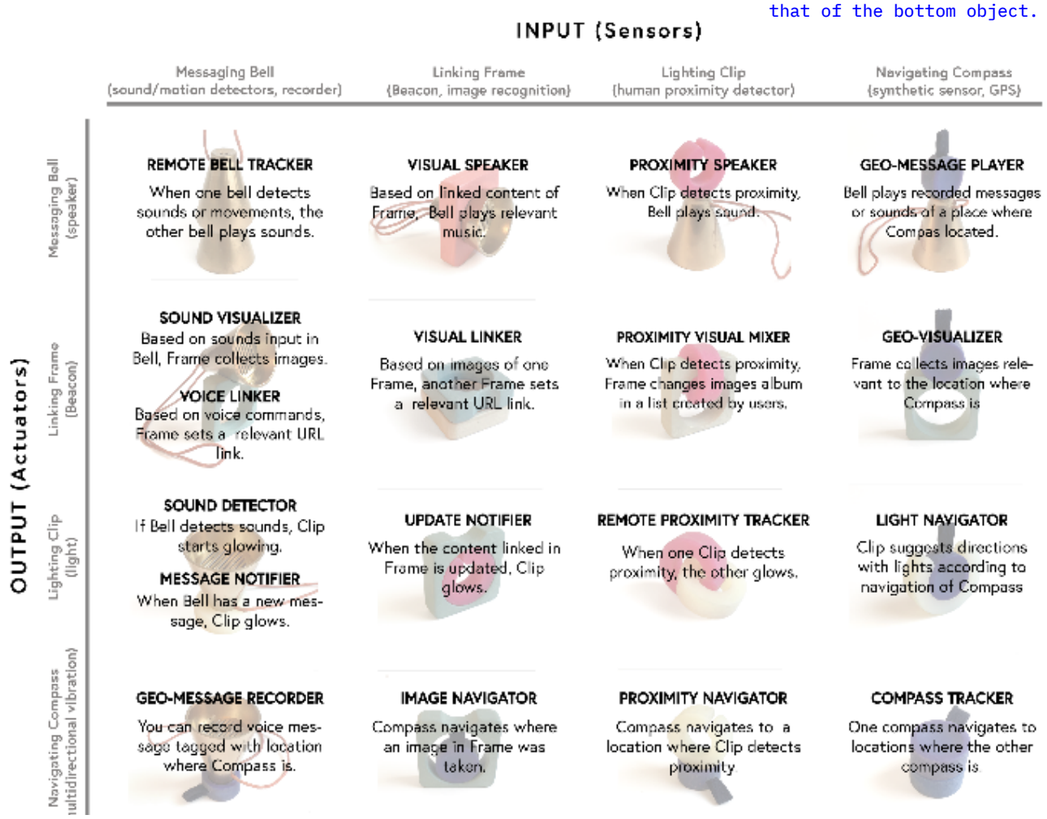


Figure 12. The four kinds of Connected Resources devices work alone as well as in combination

Figure 13. Sixteen combinations that generate different capabilities by exchanging each object's input and output functions. The combination's input is that of the top object; the output is that of the bottom object.



Four combinable objects

The functionalities of each object were upgraded; the capability of the Connected Stones was divided in two to simplify it, based on the study of openness. One capability was notifications, and the other was the suggestion of sequential directions. The interaction with the Connected Bells was also simplified so that users could record messages by directly talking to the device. As a result, the four devices of Connected Resources were aligned with four digital capabilities: (1) storing and linking images, (2) recording and playing audios, (3) notifying, and (4) navigating directions. To use signifiers as entry points to explore personal adaptations, icons were matched to objects based on use and included a photo frame, a bell, a clip and a compass. These icons were used to define sensors and actuators embedded in the objects (see pages 2 and 3 for the detailed functions of each object and Figure 13 for sensors and actuators). Inspired by the combination of uses found in the variety of use study, combinable objects were developed, which generated new functionalities among devices (Figure 12&13).

Interaction Qualities

Experiences users should have while interacting with the artefacts were categorised as familiar, simple and playful, which came from the study of openness for resourcefulness. More specifically, familiarity referred to the artefacts' resemblance to everyday objects and materials that older people use as resources in their homes, which helped them feel confident to explore personal adaptations of Connected Resources based on their past experiences. Simplicity referred to how easily Connected Resources was understood and used and was based on single features and limited content and interactions, as well as a lack of complicated configurations. Playfulness was intended to inspire users to try Connected Resources, combine devices and explore configurations for unique situations to discover new uses suitable for various and changing needs and interests among users.

Design Properties

The design properties, such as shape, material and colours, were based on the results of both studies. The objects were designed as geometrical shapes so that users could easily combine them and to communicate the devices were combinable (Figure 14a). Materials were chosen to give users and objects playfulness through the use of a variety of textures and to ensure durable for outdoor use (Figure 14b). Colours were also chosen for playfulness and for their resemblance to everyday objects in users' homes (Figure 14c). The size of the objects was designed to resemble everyday, mobile tools that could be shared with others or used together. The name of each object, also an essential design property, was carefully considered to communicate what each object was and how it worked. The look and feel of the application were also based on interactive qualities. The data visualisations for learning and sharing new device uses from others were designed with simple and understandable graphics, while the user interface was designed to be familiar and to meet current standards. Playfulness was realised in the animations used in the instructions provided for Connected Resources.

Video shooting with mock-ups

Since testing those interaction designs of Connected Resources in real life needed tremendous technical efforts with emerging technologies, we first focused on speculating on possible interactions between the new artefacts and people in everyday life (Bleecker 2009; Rosendaal et al 2018). Thus, the second models were created as mock-ups, making use of which an experimental video was created.

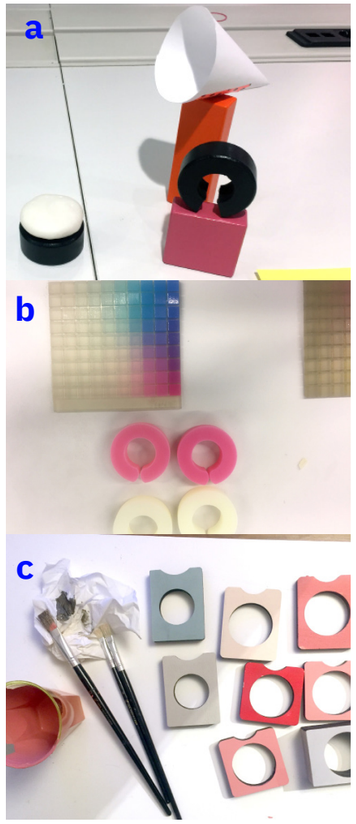


Figure 14 a, b, c. Shapes, materials and colours were tested and determined based on the three interaction qualities and insights from the studies.

The URL of the experimental video
https://vimeo.com/264771383

7. Reflection on what knowledge were generated by RtD

Openness, variety and independence in the design of technology support older people's resourcefulness

An RtD approach was suitable for this project because resourcefulness is relatively understudied and challenging to capture due to its spontaneous nature and social sensitivity. Engaging participants with prototypes in the several activities and engaging with resourcefulness through the designed activities allowed the researchers to observe resourcefulness and to understand design for resourcefulness that enables users to situate and negotiate device use with a certain degree of freedom. The following sections provide a reflection on what knowledge was generated through the RtD and how it was applied to each activity.

Dimensions of openness for resourcefulness based on subjective perceptions of objects

Five dimensions that should be open and five dimensions that should be closed when designing for resourcefulness were determined. First, ten dimensions spanning two extremes were identified in the literature. Second, the participants and researchers evaluated the dimensions using the artefacts to recommended positions, either open or closed, for resourcefulness. The openness or closedness suggested by participants provided necessary design qualities, including familiarity, simplicity and playfulness. These were translated as design properties and implemented in the second model of Connected Resources. Moreover, the discovery of the need for a certain level of clarity in signifiers for resourcefulness affected important design properties, such as giving objects semiotics of everyday tools and familiar names.

The research materials, prototypes and other artefacts informed subjective perceptions towards the objects (Stappers & Giaccardi 2017). The knowledge was successfully gained by participants' experiential engagement with materials as well as through questions prompted by such experiences. Participants were encouraged to articulate the effects of openness or closedness on dimensions of the artefact and their resourcefulness to better understand why dimensions should be open or closed. For example, a closed signifier works as an entry point to explore personal adaptations.

Variety of uses based on possible future situations

In the participatory workshop, in which participants used the prototypes, knowledge was gained about the variety of uses of the devices, from which six dimensions of variety were identified. These informed the second models of the Connected Resources and their functionality, such as making them combinable, and design properties, such as the object size for mobile use and the durability of materials for both outside and inside use. The prototypes were used to determine future uses (Stappers 2013) and to capture further insights into the practices of resourcefulness of the participants. This was achieved by having the participants imagine uses for the prototypes in their valued practice as well as in future 'everyday crises of routine' (Kuijer, Giaccardi & Nicenboim 2017; Reckwitz 2002), using the future cards. Participants imagined new capabilities for the prototypes beyond current ones, such as use with crowd-generated content, which inspired the second model. During the workshop, participants explored the prototypes current capabilities and were encouraged to conceive new ones

to achieve what they wanted to do with the prototypes in future situations. This was led by the prototypes being combined with co-design tools, which effectively generated contextual knowledge and provided design opportunities based on lived experiences (Sanders & Stappers 2012).

Tacit need to control the level of independence from technology

The workshop highlighted that older people had a nuanced meaning of independence from technology. Their narratives about using the prototypes in future situations inspired new artefact designs such as using a cloud system for the application to allow users to adjust the level of responsibility between them and the technology. Knowledge was also successfully gained through carefully designing the workshop and prototypes to allow participants to experience the technology in perceived future situations and to encourage them to share their thoughts and ideas.

8. Future Direction

Based on openness, variety and independence from technology, the second prototype of Connected Resources generated alternative possible worlds (Wakkary et al. 2015; Wakkary et al. 2016). Being experimental, the fictional prototype opened up new design spaces for future work (Stappers & Giaccardi 2017).

Future work will explore whether the second iteration of Connected Resources, which was re-designed with openness and closedness for resourcefulness and variety of use, could support various situations that older people face in real life. Since the insights gained in the two studies have limitations: they had done in the laboratory settings, we need to verify the correctness of the results of the two studies in a real-life environment with working prototypes. In particular, with these results from the real-setting, we would like to carefully relate with and untie established accounts that countered some of the results that we concluded in the experimental study of openness. For example, Gaver's argument of ambiguity (Gaver et al. 2003) countered our conclusion in that study; a closed signifier works as an entry point to explore personal adaptations.

Another area for future work is to determine how older people co-perform valuable practices with connected objects. As discussed, touch points are how older people determine the best division of roles and responsibilities between them and technology based on their own use patterns visualised by machine learning and data collected from objects. However, there is still room to study the design of these touch points, such as the timing of control, ways of control and the user interfaces, to create an appropriate interplay of co-performance between human and intelligent artefacts (Kuijer & Giaccardi 2017).

The other area for future work is to explore personal adaptations of resourcefulness in groups, in which resourcefulness is used to create higher-level community value. For example, in a study of online platform for sharing tools, exchanging knowledge and experiences of use of the tools among users helped to reinforce the community value over time (Fedesov et al. 2018). This area involves further design exploration; how the online platform makes members' activities and the level of social disclosure of personal profiles visible, since these aspects affect long-term cooperation (Fedesov et al. 2018).

References

Abel, B.V., Evers, L., Klaassen, R., Peter, T. (2011). Open design now: Why design cannot remain exclusive. BIS Publishers, Amsterdam.

Botero, A., Kommonen, K. H., & Marttila, S. (2010). 'Expanding design space: Design-in-use activities and strategies'. In Proceedings of the DRS Conference on Design and Complexity.

Dunne, A., & Raby, F. (2013). Speculative everything: design, fiction, and social dreaming. MIT press.

Fedosov, A., Odom, W., Langheinrich, M., & Wakkary, R. (2018, June). 'Roaming objects: Encoding digital histories of use into shared objects and tools'. In Proceedings of the 2018 Designing Interactive Systems Conference (pp. 1141-1153). ACM.

Gaver, W. (2012, May). 'What should we expect from research through design?'. In Proceedings of the SIGCHI conference on human factors in computing systems (pp. 937-946). ACM.

Gaver, W. W., Beaver, J., & Benford, S. (2003, April). 'Ambiguity as a resource for design'. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 233-240). ACM.

Giaccardi, E., Cila, N., Speed, C., & Caldwell, M. (2016, June). 'Thing ethnography: Doing design research with non-humans'. In Proceedings of the 2016 ACM Conference on Designing Interactive Systems (pp. 377-387). ACM.

Giaccardi, E., Kuijer, L., & Neven, L. (2016, June). 'Design for resourceful ageing: Intervening in the ethics of gerontechnology'. In Design Research Society 50th Anniversary Conference.

Hyysalo, S. (2006). 'Representations of use and practice-bound imaginaries in automating the safety of the elderly'. Social Studies of Science, 36(4), 599-626.

Ingold, T. (2012). 'Toward an ecology of materials'. Annual review of anthropology, 41, 427-442. DOI: 10.1146/annurev-anthro-081309-145920

Kuijer, L., & Giaccardi, E. (2018, April). 'Co-performance: Conceptualizing the role of artificial agency in the design of everyday life'. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (p. 125). ACM.

Kuijer, L., Nicenboim, I., & Giaccardi, E. (2017, June). 'Conceptualising resourcefulness as a dispersed practice'. In Proceedings of the 2017 Conference on Designing Interactive Systems (pp. 15-27). ACM.

Lindsay, S., Jackson, D., Schofield, G., & Olivier, P. (2012, May). 'Engaging older people using participatory design'. In Proceedings of the SIGCHI conference on human factors in computing systems (pp. 1199-1208). ACM.

Nicenboim, I., Giaccardi, E., & Kuijer, L. (2018, June). 'Designing Connected Resources for Older People'. In Proceedings of the 2018 on Designing Interactive Systems Conference 2018 (pp. 413-425). ACM.

Nicenboim, I., Kitazaki, M., Kihara, T., Torralba Marin, A., & Havranek, M. (2018, April). 'Connected resources: A novel approach in designing technologies for older people'. In Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems (p. D202). ACM.

Reckwitz, A. (2002). 'Toward a theory of social practices: A development in culturalist theorizing'. European journal of social theory, 5(2), 243-263.

Sanders, E. B. N., & Stappers, P. J. (2012). Convivial toolbox: Generative research for the front end of design. Amsterdam, BIS.

Sengers, P., & Gaver, B. (2006, June). 'Staying open to interpretation: engaging multiple meanings in design and evaluation'. In Proceedings of the 6th conference on Designing Interactive systems (pp. 99-108). ACM.

Soro, A., Ambe, A. H., & Brereton, M. (2017). 'Minding the gap: Reconciling human and technical perspectives on the IoT for healthy ageing'. Wireless Communications and Mobile Computing, 2017.

Stappers, P. J. (2013). 'Prototypes as central vein for knowledge development'. Prototype: Design and craft in the 21st century, 85-98.

Vaisutis, K., Brereton, M., Robertson, T., Vetere, F., Durick, J., Nansen, B., & Buys, L. (2014, April). 'Invisible connections: investigating older people's emotions and social relations around objects'. In Proceedings of the 32nd annual ACM conference on Human factors in computing systems (pp. 1937-1940). ACM.

Wakkary, R., Lin, H., Mortimer, S., Low, L., Desjardins, A., Doyle, K., & Robbins, P. (2016, June). 'Productive frictions: Moving from digital to material prototyping and low-volume production for design research'. In Proceedings of the 2016 ACM Conference on Designing Interactive Systems (pp. 1258-1269). ACM.

Wakkary, R., & Maestri, L. (2008). 'Aspects of everyday design: Resourcefulness, adaptation, and emergence'. In Journal of Human–Computer Interaction, 24(5), 478-491.

Wakkary, R., Odom, W., Hauser, S., Hertz, G., & Lin, H. (2015, August). 'Material speculation: actual artifacts for critical inquiry'. In Proceedings of The Fifth Decennial Aarhus Conference on Critical Alternatives (pp. 97-108). Aarhus University Press.