

Design of a novel interactive textile tool for Dementia Care: Improving sensory interventions with Multi-sensory Illuminated Cushions

Abstract

In dementia care, multi-sensory stimulation is a widely adopted non-pharmacological intervention that supports emotional wellbeing, engagement, and social interaction, especially in later stages of the disease. However, existing sensory tools often stimulate only a single sense and are not specifically designed with the needs of older adults in mind. To address this gap, this study presents the design and development of a novel interactive textile tool—the Multi-sensory Illuminated Cushions (MICs)—using a multidisciplinary co-design process involving textile designers, engineers, and occupational therapists (OTs). The MICs are portable cushion-based devices that integrate smart textiles with capacitive touch sensing, RGB illumination via polymeric optical fibres (POFs), and audio playback. Developed with human-centred design principles, they offer intuitive, multi-sensory engagement through light, sound, and tactile interaction, tailored for individuals with late-stage dementia. Four MIC prototypes were evaluated in clinical settings by OTs during sensory stimulation sessions. Results showed that participants demonstrated significantly higher engagement levels with MICs compared to a market-available sensory cushion, as measured by the Observational Measurement of Engagement (OME). Positive emotional and behavioural responses were observed from all users. The key innovation of this study lies in combining scalable textile manufacturing with embedded interactive electronics in a washable, modular, and user-comfort-oriented form. Unlike previous handcrafted or fixed installations, MICs offer a practical, adaptable, and production-ready solution for dementia care environments. This research contributes a novel framework for integrating smart textile technology into dementia-focused design and highlights the value of collaborative, human-centred methods for developing inclusive healthcare tools.

Keywords: smart textile, dementia care, sensory intervention, knitting technology, multidisciplinary co-design process

Introduction

The rapid rise in the number of people suffering from dementia shows a critical worldwide dilemma, emphasising the urgent need for increased research and development focused on assisting these vulnerable communities in need of care. Dementia is a complex syndrome primarily impacting older adults, marked by the progressive decline of cognitive functions beyond what is considered normal ageing.¹⁻³ It covers a range of symptoms, including memory loss, behavioural changes, and disruptions in daily living activities, which ultimately lead to a decline in an individual's ability to function independently.⁴⁻⁶ The global circumstance is alarming. The World Health Organisation estimates that over 55 million people are currently living with dementia, with nearly 10 million new cases arising each year.⁷ If current trends continue, this number is expected to double by 2050, placing immense pressure on healthcare systems worldwide. In Hong Kong, the situation is equally concerning.⁸ According to the Hong Kong Alzheimer's Disease Association, there were approximately 103,433 individuals living with dementia in 2009, a figure that is projected to increase to over 300,000 by 2039.⁹ A comprehensive chart listing and trend analysis of the percentage change in the number of individuals with dementia globally and by world region between 2019 and 2050 has been conducted in the study.¹⁰ This pressing public issue requires immediate action. Individuals with dementia need specialised care, medical attention, and a variety of support services, indicating a demand for dementia care practices.¹¹ It is critical that dementia care extends beyond merely addressing the patients' medical and physiological aspects but also maintaining their social engagement, emotional well-being, and general life satisfaction.¹² Compared with pharmacological interventions that typically rely on medications to manage behavioural symptoms, non-pharmacological interventions aim to support patients through therapeutic engagement, environmental adjustment, and emotional support without the risk of side effects.¹³ While drug treatments may offer temporary symptom relief, they can also lead to adverse effects such as sedation or increased fall risk. In contrast, non-drug interventions are designed to promote meaningful interaction and cognitive stimulation in a safer and often more person-centred manner. Investigations on non-pharmacological interventions in dementia care, and person-centred approaches to meet the specific needs of people with dementia can aid in improving their overall quality of life.^{14, 15} Apart from sensory stimulation, other common non-pharmacological interventions include music therapy, reminiscence therapy, doll therapy, animal-assisted therapy, and validation therapy.¹⁶ Each approach provides therapeutic benefits depending on user preference, environment, and care objectives. However, many of these

interventions are often limited to single-sense stimulation, require specialised facilitators, or are difficult to personalise. In comparison, this study presents a technology-enhanced solution combining tactile, visual, and auditory engagement within a single portable and customisable design that can be easily operated by regular caregivers. In addition, dementia-specialised researchers suggested that the integration of technology in dementia care could play a key role in enhancing individual engagement and personalising care approaches.¹⁷ Thus, applying technology to develop innovative solutions tailored to the unique needs of this growing population is imperative.

Sensory interventions used for dementia care require substantial improvements in design and functionality to be more adaptive to elderly individuals with dementia. Sensory stimulation is a specialised approach that stimulates various senses, including touch, sight, hearing, smell, and taste¹⁸⁻²⁰, which is widely employed in dementia care.^{21, 22} It incorporates sensory interventions within multisensory environments or through targeted sensory stimulation activities to increase participants' alertness and reduce their agitation.²³ The application of sensory interventions by occupational therapists (OTs) has been shown to enhance engagement levels in individuals with dementia, promoting positive emotions.²⁴ By facilitating interactions with sensory interventions, carers can generate positive effects on moods and decrease the behaviours of people with dementia, thereby improving their overall well-being and quality of life.^{18, 22, 25} However, despite the potential benefits, many of the sensory interventions currently available possess notable limitations, which could not meet the complex needs of their intended users. Most are designed to target only a single sense at a time, limiting their effectiveness in providing comprehensive sensory engagement.²⁶ Furthermore, market-available sensory tools often lack a human-centred design approach, which fails to consider the specific preferences and capabilities of people with dementia, particularly in the later stages of the condition. The tools used in sensory stimulation for older adults with dementia need to be distinguished from those for children and should be designed appropriately for adults, considering their needs and dignity.^{18, 27} In high-density areas like Hong Kong, the situation is even less optimistic. Due to space constraints and limited resources, the implementation of fixed, large-scale sensory tools is difficult. Many dementia care settings in Hong Kong struggle to establish dedicated multisensory environments, further limiting the quality of care. Given these challenges, the development of portable, multifunctional sensory tools that can be easily adapted to different care settings may provide a practical solution. This study introduces a novel smart textile-based solution that addresses several important limitations seen in previous interactive textile tools.

Compared to existing designs such as the “Tactile Dialogues” pillow and the “Sensor e-textiles” artefacts,^{28,29} the MICs offer improvements in both scalability and functionality. Notably, the MICs combine capacitive sensing, light-reactive POFs, and audio features within a knitted soft-textile form that ensures comfort, intuitive interaction, and safety for elderly users. Unlike hand-crafted artefacts or fixed wall panels that are space-dependent and not easily duplicated,^{30, 31} the MICs are designed for industrial manufacturability, modular use, and user personalisation—supporting flexible deployment across diverse dementia care environments. Furthermore, their ability to deliver multi-sensory stimulation in a portable cushion form represents a unique innovation in the field.

Utilising smart textile technologies in sensory design for dementia care offers a novel and feasible approach to enhancing the design, properties and functions of sensory tools. The concept of smart textiles revolves around integrating traditional fabrics with electronic components and other functional materials to enhance their performance and capabilities.³²⁻³⁴ The third generation of smart textiles is known as Very smart textiles, incorporating control units that enable a range of functionalities, including sensing, actuating, and responding to stimuli.^{35,36} These remarkable capabilities allow smart textiles to perceive and adapt to changes in their environment, and interact with users, which have transformed textiles into an interactive system with new applications.³⁷ The evolution offers significant opportunities for creating textile-based sensory tools that are not only versatile but also tailored to the specific needs of individuals with dementia. A practical and accessible risk prediction model was developed using machine learning algorithms and deployed as a web-based application, offering a novel and user-friendly tool for predicting dementia risk in middle-aged and older adults with depression.³⁸ The research by Anke and Lesley³⁹ also highlights the immense potential of using smart textile technologies for dementia design, as there is interactivity and the possibility of enhancing sensorial qualities. Using textiles as a medium to develop sensory tools for dementia care offers several advantages, particularly due to their inherent familiarity, softness, and flexibility. The elderly, especially those with cognitive impairments, thereby are more receptive to the embedded advanced technologies. Furthermore, textiles exhibit a wide range of variations and can be presented in diverse forms, facilitating the seamless integration of electronic components to achieve multiple sensory features into a single design, enhancing the overall sensory experience. While the advantages offered by smart textile technologies are obvious, there is surprisingly limited research on their application and exploration to develop enhanced sensory tools for dementia care. For instance, the “Tactile Dialogues” project

presented the development of a textile pillow that specifically aims to encourage non-verbal communications between elderly individuals with late-stage dementia and their family members or carers.²⁸ When the sensors are activated by touch, the pillow reacts with vibration to provide movement stimulation. This project serves as a reference to design sensory tools with smart textiles, but it did not explore the possibilities of providing multi-sensory stimulation, which might be more beneficial in dementia care. Another recent example is the “Sensor e-textiles” project, which introduced human-centred sensory textile artefacts integrated with electronics that were also designed for people with dementia in later stages.²⁹ With the embedded electronic components, sound stimulation is available and can even be customised to the user's favourite songs. Textile technologies, such as digital printing, were used to embed personalised items into the textile artefacts, such as photographs and personal objects. While the developed artefacts have been found to have positive impacts on the users, they are simple handcrafted textiles, which are not scalable for production. One noteworthy example is the research by Tan and her colleagues,⁴⁰ which explored the integration of intelligent textiles into the design of a sensory wall panel for dementia patients. The project incorporated the illuminated POF fabrics, electronic components, and the use of textiles with different textures to create a multi-sensory tool, significantly enhancing the users' sensory experiences. The functions were designed to be activated through intuitive interaction with the touch-reactive surfaces that applied interactive textile elements. However, while innovative, the final design is a large, fixed wall panel that requires ample wall space and specific setup conditions for installation, making it impractical for most dementia care settings in densely populated regions like Hong Kong. Such large-scale designs possess significant limitations in terms of feasibility and adaptability within real-world care settings. The limitations of previous studies highlight a critical gap in the research and development of interactive textile designs for multi-sensory tools that can be easily integrated into various dementia care settings. This study directly addresses that gap by delivering a novel prototype that overcomes common challenges in user accessibility, scalability, technological integration, and care-setting adaptability—contributing an innovative and human-centred alternative to both existing textile-based and non-pharmacological dementia interventions.

This research focuses on studying how to design a textile tool for the elderly with late-stage dementia by leveraging smart textile technologies, which can enhance their sensory experiences and interactions and be adapted to care settings despite space constraints and limited resources. A multidisciplinary co-design process involving textile designers, dementia

care professionals, and engineers was structured to gather impactful ideas for dementia care innovations and transform them into textile creatures. Carers, being key stakeholders in dementia care, can offer invaluable insights through their extensive experience and professional knowledge during the design process, contributing to the development of an interactive textile tool that enhances user engagement and interaction.⁴¹ The final outcomes aim to be both feasible and effectively meet the specific needs of the target users while aiding in dementia care. The key novelty of this research lies in the creation of an entirely textile-based, soft, and interactive system using real-time capacitive sensing, RGB LED lighting via incorporated POF, and embedded music playback—all housed in comfortable, familiar cushion forms. Unlike earlier textile-based sensory tools that rely on handcrafted methods or fixed installations, this study proposes a scalable, modular, and detachable design that addresses hygiene, portability, and long-term use—critical factors often overlooked in prior work. The framework of the co-design process is illustrated in Figure 1., which follows the double diamond design process and includes four main stages:⁴² discover, define, develop and deliver. The first phase was to understand the background and explore the problems of sensory interventions in dementia care through literature reviews, exploration of current sensory tools, and a semi-structured interview with a collaborative OT. In the second stage, a research gap and research question are identified, followed by design planning that includes analysing ideas generated from the interview to define requirements and establishing design principles. The interactive textile tool was then designed in the next phase, and they were developed by textile designers and engineers and refined with the collaborative OT. The final stage involved finalising the design, clinical application of final prototypes by the collaborative OTs and evaluation compared with a market-available sensory cushion.

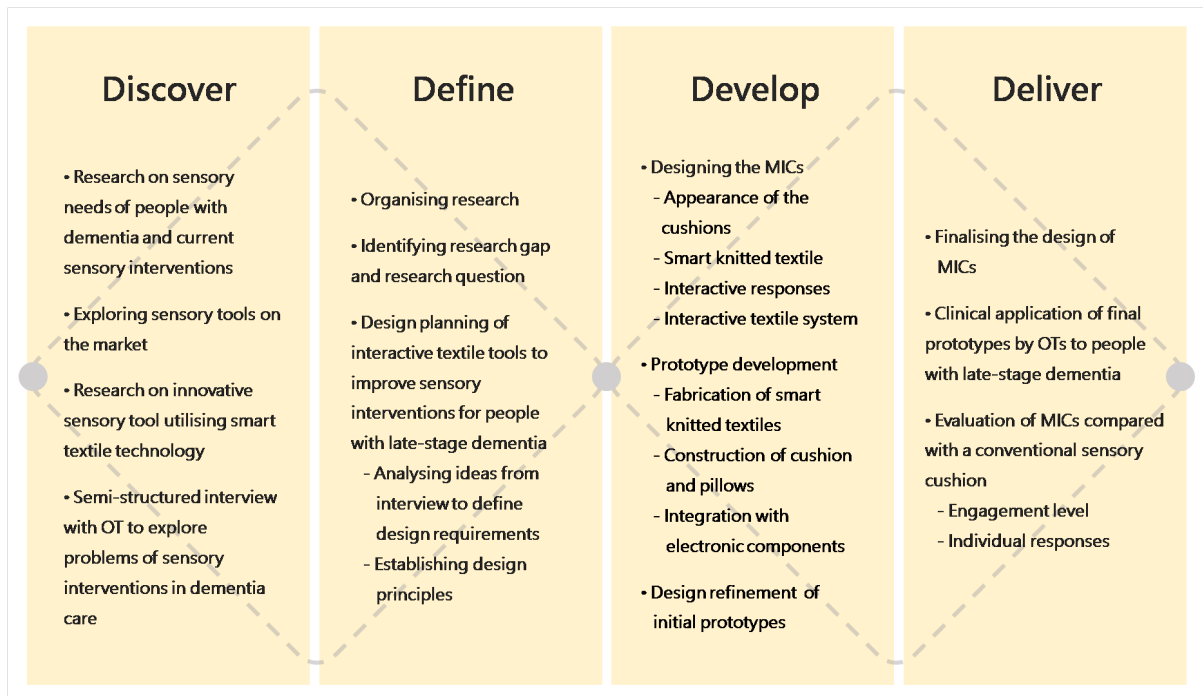


Figure 1. Theoretical framework of the co-design process for the design of an interactive textile tool for dementia care

Design process

The aim of the study was to design a portable, interactive textile device that offers multi-sensory experiences for older adults at later stage of dementia through human-centred design integrating smart textile technologies.

Analysis of dementia care focuses

A semi-structured interview with the collaborative OT was conducted to generate ideas about the design requirements for the co-design process, followed by an analysis of the collected data. This method effectively gathers detailed insights into the specific needs of elderly people with dementia by analysing the concerns from the extensive real-world dementia care experience. Given the cognitive abilities and physical conditions of the intended users, the tool must be straightforward and sufficiently accessible for their use. Older adults typically experience vision impairment as they age,⁴³ which necessitates attention to the visual clarity of the design. Carers usually use a range of sensory equipment and tools to achieve multisensory experiences for dementia patients, while it would be more efficient for care settings with limited space and resources if a tool could provide stimulation to multiple senses. The tool

should also be designed to allow for flexible applications that accommodate the individual sensory perceptions of various users.⁴⁴ Cultural differences and personal preferences impact the user's sensory perception,³⁹ as well as their engagement with the sensory interventions. For instance, the collaborative OT observed that some dementia patients were reluctant to interact with robotic pets, which are common sensory tools. The design direction of the tool should focus on gaining universal acceptance while also providing customisable elements. The designated room for sensory-stimulating activities is limited in space, which requires a small-scale and portable tool. Furthermore, the tool is anticipated to serve a certain number of users, highlighting a need to maintain its hygiene, particularly for infection control purposes.

Design principles

Several design principles were established by integrating the perspectives of textile design researchers and the collaborative OT that specialises in dementia care. The design was then carried out, considering six major aspects:

Simple, clear and familiar design. To ensure the tool is accessible and intuitive for users of varying abilities, it should be designed to promote ease of use and understanding, allowing all users to interact with it smoothly.⁴⁵ In terms of appearance design, the style and silhouette need to be simple and clear. A simple motif is suitable to serve as an ornamentation for design purposes. By using common symbols as inspiration, the motif can be easily recognised by users and provide the tool with a clear theme. To enhance the visual clarity of various parts of the design, contrasting colours and distinct visual borders should be used to create apparent differences. Furthermore, the tool should be designed as a textile product that is highly familiar to dementia patients, allowing it to be seamlessly integrated into care settings and easily accepted by them.³⁹ The familiar tactile sensation of textiles can also aid in promoting relaxation among users.

Intuitive interaction. The functionality of providing interactions that rely on natural, instinctive responses from users can enhance their engagement. Intuitive interaction refers to a mode of engagement with an interface characterised by rapid, usually accurate, and somewhat non-conscious interaction, informed by users' past experience.⁴⁶ This type of interaction is intuitive, can be easily understood, and can be used without requiring explicit instructions or prior learning. For instance, reactions to touch, movement, or gestures correspond with users'

daily behaviours and experiences. Thus, it enables users to interact with the tool in a way that feels familiar and accessible, even for those with severe cognitive decline or those with cultural differences.⁴⁷ The simple approach to trigger the immediate response of the tool reduces the cognitive effort required to engage with it, thereby minimising frustration and confusion in elderly individuals with dementia who may struggle with complex instructions. By removing barriers to cognitive abilities and individual conditions, intuitive interaction fosters user engagement, which supports effective sensory stimulation.

Multi-sensory stimulation. Textiles provide inherent multi-sensory experiences, whereas applying smart textile technology can enhance them and bring novelty.³⁹ The textile tool can offer vision stimulations in depth through a variety of optical properties, including lustre, texture, reflection, and motif design. Different kinds of fabrics can provide tactile stimuli for users through their inherent haptic properties, while fabrics with contrasting textures can further emphasise these differences. The evolution of smart textile technology enables the use of illuminated textiles within the tool, enhancing visual stimulation by means of light. Illuminated textiles, also called photonic textiles, which integrate advanced materials and electronic devices, are equipped with the capability of emitting light, changing colours, and displaying patterns.⁴⁸ Furthermore, electronic components for creating vibration or sound can be incorporated, which allows for stimulations other than visual and tactile. Despite the aim of addressing all senses for appropriate multi-sensory experiences, the sensory stimulation provided by the tool remains constrained by textile technology and the control of size and weight for portability. This study is going to explore the possibility of providing stimulation to multiple senses via a portable interactive textile tool.

Portable and Flexible application. The application of the tool needs to accommodate a wide range of environments and individuals. A small-scale and lightweight design allows it to be portable and adaptable to various settings. However, the tool integrated smart textile technologies, which consist of multiple electronic components, to achieve advanced functions for multi-sensory stimulation and interaction. While facing this limitation, the design should control the size without affecting the seamless integration of the electronic parts. Although the multi-sensory stimulations of the tool can provide comprehensive sensory experiences, it cannot suit every user if its application is only one way and always the same. Sensory perception varies among individuals, with some exhibiting heightened sensitivity in certain areas compared to others, and some experiencing senses declining as they age, and dementia

progresses.⁴⁹ For a personalised care approach, the tool must be able to be applied flexibly by carers based on the user's conditions and responses.

Customisable approach. It is important to consider whether the design could allow for a reliable, scalable, and even customisable approach to production or not. People are seeking methods that are both innovative and cost-effective to enhance the well-being of those with dementia.⁵⁰ The knowledge of textile technology should be used to consider practicality and construct the design in a way that can realise mass production. Additionally, an approach enabling multiple customisable design elements within the tool can easily adjust the design according to an individual's preference. By adding a sense of users' personalities within the tool, their engagement during the sensory activities can be enhanced.⁵¹ In terms of an interactive textile tool, there are numerous options available for fabric colours, motif designs, interactivity, and advanced functions, facilitating customisation results in personalised sensory experiences.

Easy care in laundering. Interactive textile tool design must prioritise the ease of cleaning. Maintaining sanitary conditions for textiles employed in dementia care is crucial for minimising the risk of infection. Microbial species will be brought to the interactive textile tool through skin contact by holding and touching it during the sensory-stimulating activities. Appropriate laundering process is an infection prevention practice that effectively removes and inactivates microorganisms on textiles in healthcare facilities.⁵² However, smart textiles contain electronic components that cannot withstand washing, which highlights the need to design the connection between those components and the textile parts that contact the users as removable. The selection of textile materials should also consider whether they are machine washable.

Design planning of interactive textile tool for dementia care

To address the limitations of traditional sensory tools in dementia care, a structured experimental plan was developed to guide the creation and evaluation of interactive textile tools tailored to users in the later stages of dementia. The plan consisted of the following key phases:

1. A multidisciplinary co-design process was established, engaging textile designers, dementia care professionals (such as OT), and engineers. This phase facilitated the collection and integration of user-centred insights, professional expertise, and technological capabilities. The co-design workshops focused on identifying sensory preferences and practical considerations for use in dementia care environments.
2. Prototyping was conducted to develop a collection of portable MICs. These cushions were designed using knitted textiles integrated with POFs and capacitive sensing technology. The MICs incorporated multimodal sensory elements—primarily visual (light-based), tactile (textural and responsive to touch), and auditory (music and sound)—intended to promote engagement and intuitive use among people with cognitive impairments.
3. The primary design goal of the MICs was to align with principles of human-centred design, ensuring the prototypes were not only technologically feasible but also effective in meeting the varying sensory and emotional needs of older adults with dementia. Aesthetically and functionally, the designs sought to encourage interaction while maintaining comfort and familiarity.
4. The subject test involved testing four distinct MIC prototypes during multi-sensory stimulation sessions with residents in the later stages of dementia. This phase was conducted by OT in real-world care settings. To assess their effectiveness, a market-available vibration cushion commonly used in sensory therapy served as a control or baseline product.
5. Comparative performance evaluation was carried out using the Observational Measurement of Engagement (OME) to assess participants' engagement levels. Both objective and subjective data, including professional feedback from OTs, were collected to evaluate the effectiveness and practicality of the MICs in enhancing multi-sensory engagement.

This iterative, experimental approach enabled the development of sensory interventions grounded in clinical relevance, technical feasibility, and user empathy.

Design of the Multi-sensory Illuminated Cushions

The interactive textile tool that fulfils the design principles has been realised through the design of a collection of portable multi-sensory illuminated cushions (MICs). The MICs seamlessly integrate smart textile technology to improve the well-being of individuals with late-stage dementia, and they can be adapted to different care settings. Cushions are a common textile product in care settings that are portable and can provide the elderly with a secure and warm feeling when they are holding them. Before the implementation of design modeling and physical prototyping, several assumptions and modifications were made to optimise feasibility and user safety. Firstly, it was assumed that care environment conditions—such as ambient noise levels and lighting—might vary, and therefore the audio and visual outputs were calibrated to moderate, non-intrusive levels suitable for most aged care settings. Secondly, users were expected to interact with the cushion in a casual, non-instructed manner; therefore, touch-sensitive zones were positioned in naturally reachable areas based on ergonomic proportions. Assumptions were also made regarding user strength and motor limitations, prompting the design of low-force capacitive touch activation. In addition, the textile-electronic integration model assumed that textile parts would need periodic removal for laundering, leading to the adoption of detachable connectors. Finally, as a practical design constraint, materials were selected under the assumption that components must be sourced using commercially available, healthcare-conscious materials that meet safety standards. These assumptions guided the modeling phase and informed modifications during the technical integration process. Four MIC prototypes are designed and developed in this study, each with unique properties while being cohesive in design and sharing a similar interactive textile system. The design of four MIC prototypes is divided into four parts, demonstrating how the design of each part conforms to the design principles.

Appearance design of the cushions

Visual ornamentation. Each style of MICs is decorated with one main motif in the middle of the front side. The motifs are designed with simple symbols that represent positive emotions or nature. They are outlined with clear visual borders to make them stand out from the background, highlighting the visual clarity. Sharp and contrasting colours are applied on the edges to enrich the vision stimuli.

Figure 2a(i) illustrates style 1, which features a yellow "smile" outlined by grey borders on a pastel pink background with contrasting light blue edges. Style 2 (Figure 2a(ii)) is designed as a "star" in yellow with grey borders, a light blue background, and contrasting sharp pink edges. Figure 2a(iii) is the design for style 3, with a pink "heart" and grey outlines. The background is purple, and the edges are contrasting in light yellow. Style 4 is illustrated in Figure 2a(iv), featuring a "flower" with purple petals and a yellow core. The yellow colour is used as the background, and the light purple colour is used as the edges to show contrast. Figure 2b shows the back side of the cushions, which is plain and in the same colours as their edges in the front.

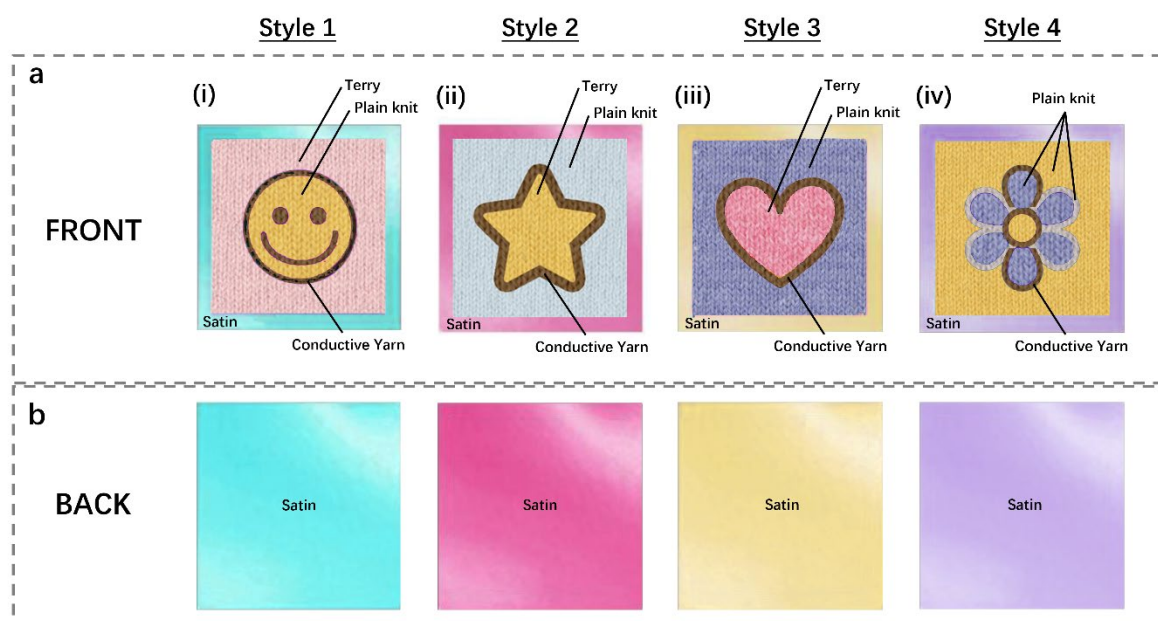


Figure 2. Illustration of MICs' design

Textile application. The design incorporates different types of textiles in different parts, which can enhance the visual experience and, most importantly, provide touch stimulation through contrasting textures. Knitted textiles seamlessly integrated with smart textile technology are the main part of the cushions. The tactility of knitted textiles is soft and reassuring. Suitable approaches are utilised for incorporating functional materials into the smart knitted textiles to achieve illumination and interaction without affecting the haptic experience. Apart from the texture provided by plain knit structures, a rough and towel-like texture is created by applying Terry structures to the knitted textiles. As shown in Figure 2a, style 1 consists of plain knit structures in the motif and borders and Terry structures in the background, while styles 2 and 3 comprise Terry structures in the motifs and plain knit structures in the borders and background.

Moreover, style 4 solely employs plain knit structures. Satin fabrics are used on the edges of the front side and the entire back side of all the cushions (Figures 2a & 2b). These silky and lustrous fabrics feel smooth against the skin.

Touch-reactive and illuminated area. To integrate advanced functions that facilitate interactivity, it is also necessary to ensure the aesthetic appeal of the design. Therefore, the touch-reactive areas are positioned on the borders (Figure 2a). The colour of the conductive yarns can then be merged with the grey colour of the borders, preventing its brownish colour from affecting the motifs and backgrounds. Meanwhile, style 4 features a multi-touch-reactive function. Thus, the touch-reactive area is divided into three sections with a certain distance between them (Figure 2a (iv)).

POF textile is utilised to create illuminated effects that enhance vision stimulation. Light emission in polymer optical fibres is based on total internal reflection and side-light diffusion, which can be achieved through controlled surface abrasion or micro-perforation, allowing illumination through flexible textile structures.⁵³ The use of such novel materials surprises users and encourages them to engage. The brightness of knitted POF textiles varies from different knit structures. The fullness and thickness of Terry structures block the light of the integrated POF. Furthermore, the degree of yarn colour shade influences the brightness, while a lighter shade causes a higher level of brightness. The illuminated area of style 1 is located in the motif, whereas it is in the background of styles 2 and 3 (Figure 2a (i, ii, iii)). In style 4, the entire POF textile is the illuminated area, with the exception of the area containing conductive yarns (Figure 2a (iv)).

Design of the smart knitted textile

The smart textile employed in the main section of the MICs includes an innovative knit design that allows the incorporation of textile-based yarns, POFs, conductive yarns, and integrated components, enabling illuminated and music-playing features upon touch.

Knitted POF textile with illuminated effect. In the design, POFs pass through the knitting process to produce large area illuminated knitted fabrics. POF textiles, which contain electronic components for light emission, are classified as smart illuminated textiles.⁵⁴ Side-emitting POF is designed to accomplish light leakage through mechanical or chemical damage to its surface, allowing textiles to be lighten up in the area where the fibre is integrated.⁵⁵ These lightweight,

small-dimensional, and durable filaments enable the integration with textiles that do not compromise the appearance and touch. In addition, they are safe for producing textile products, including those in direct contact with the skin, as there is no risk of electrical leakage or heat generation. Integrating POFs into textiles by knitting is effective and efficient for production, while the functionality and tactility can be enhanced when compared to woven POF textiles. The flexible nature of knitting allows for seamless POF incorporation during the fabric manufacturing process, enabling the creation of illuminated textiles that can be stretched, shaped, and draped while retaining their illuminative properties. Moreover, the inherent stretchability and breathability of knitted fabrics provide a significant advantage, making them ideal for producing the MICs.

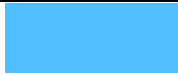
Knitted textile with capacitive sensing. To create interactions that users can engage with in an intuitive way, knitted areas are embedded with conductive yarn to serve as sensors. With an integrated controlling unit, the smart knitted textile can execute the illuminated and music-playing functions when detecting touch. Knitting incorporates conductive yarns into fabrics in an approach that provides skin comfort and high elasticity compared to other techniques for manufacturing conductive textiles.⁵⁶ Conductive yarn, typically comprised of fibres with conductive materials such as metallic filaments or carbon-based materials,⁵⁷ demonstrates sensitivity to variations in electrical capacitance.⁵⁸ The changes in capacitance when subjected to physical touch can be detected by an integrated electronic circuit, allowing the textile to act as a touch-sensitive interface.⁵⁹ After connecting the conductive section to an integrated system that includes a controlling unit, the textile can perform the specified illumination or sound generation actions upon touch. The unit is capable of carrying out the programmed commands and activating electronic components within the system, such as light sources or sound devices. Specifically, when a user touches the conductive knitted area, the electrical capacitance at that point changes. This change is continuously monitored by a touch interface circuit connected to the microcontroller inside the controlling unit. Once the capacitance crosses a predefined threshold, the microcontroller interprets it as a destined touch and triggers the pre-programmed interactive response.

Design of the Interactive responses

The conductive area knitted into each MIC works as a soft switch, with the reactions activated in each of them leading to illuminated effects in different colours, while one of them also

provides soothing music. The smart knitted textile can emit light in colours of the red, green, and blue (RGB) colour model by connecting POFs with RGB light-emitting diodes (LEDs). Each RGB LED is connected to the control unit through three separate signal wires (one for each channel: red, green, and blue). Pulse Width Modulation (PWM) is used to control the brightness levels of each channel, allowing colour mixing and transitions. The LEDs receive different voltage according to the RGB colour parameters programmed into the microcontroller based on the touch input signals. The interactive response in each MIC is shown with details in Table 1. Style 1 provides illumination in orange upon touch with a colour parameter of (255, 140, 80) and plays soothing music. In Style 1, the controlling unit is programmed to trigger both LEDs and an audio output. A micro speaker is connected to the embedded audio playback module on the customised printed circuit board (PCB) controlled by the microcontroller. When activated, it plays preloaded audio stored on a microSD card. When touch is sensed, style 2 lights up in ice blue with a colour parameter of (80, 190, 255), whereas style 3 lights up in purple with a colour parameter of (150, 110, 220). The touch-reactive area of style 4 contains three sections, while upper section triggers pink lighting, the middle section triggers blue lighting, and the bottom section triggers green lighting. Their colour parameters are (255, 105, 180), (65, 105, 255), and (90, 255, 85) separately.

Table 1. Specification of MICs' interactive responses

	Touch-reactive area	Colour name	Colour	Colour parameter (R, G, B)	Music
Style 1	Conductive section	Orange		(255, 140, 80)	Soothing music
Style 2	Conductive section	Ice blue		(80, 190, 255)	Nil
Style 3	Conductive section	Purple		(150, 110, 220)	Nil
Style 4	Upper conductive section	Pink		(255, 105, 180)	Nil
	Middle conductive section	Blue		(65, 105, 255)	Nil
	Bottom conductive section	Green		(90, 255, 85)	Nil

Design of the Interactive textile system

Textile designers and engineers mutually designed an interconnected system for enabling the cushions to offer multi-sensory experiences through touch-sensitive feedback, which incorporates smart knitted textiles and multiple electronic components to perform specific functions. Figure 3a is the conceptual diagram that illustrates the system's design. The controlling unit serves as the central processor of the system that controls the connected devices based on programmed commands, including interpreting input signals and executing the corresponding actions. The computer programs are developed by engineers according to the requirements of touch-reactive functions and interactive responses for each MIC. A self-developed PCB for the control unit contains a microcontroller, a capacitive sensing module, an RGB LED driver circuit, and, in Style 1, an audio interface. The capacitance sensing module feeds data to the microcontroller in real-time, which runs firmware programmed using C++. The program maps specific input values to output behaviours, such as triggering LED lighting or audio playback. The firmware also manages signal routing and power regulation to the RGB LEDs and audio module. The conductive section embedded in the smart knitted textile is connected to the controlling unit, acting as a touch-reactive interface. Moreover, style 4 has three separate conductive sections, and each of them is individually connected to the unit. The section continuously reads the capacitance value. Then, the controlling unit receives and processes the data. When the received value falls within the designated range, which indicates variations caused by human touch, the controlling unit will respond by activating the RGB LEDs or even the micro speaker.

In order to achieve the desired illumination, the control unit adjusts the power supply to the RGB LEDs based on the corresponding colour parameter. The POFs integrated into the smart knitted textile extend beyond the fabric's edges by a certain length, allowing further finishing to form a bundle that can be attached to the RGB LEDs. After connecting with light sources, the surface of the smart knitted textile provides an illuminated effect. For style 1, the system incorporates an additional micro speaker, enabling the execution of audio feedback by playing pre-set music. The RGB LEDs are connected directly to the customised PCB inside the 3D-printed control unit box. Figure 3b shows the diagram of working process and components in the intelligent knitted textiles.

The electrical power for the controlling unit is provided by the connected power supply, which is then delivered to other components, ensuring continuous operation of the system.

Additionally, the connections between the smart knitted textile and the electronic components are designed to be easily unattached. Thus, the textile can be cleaned by laundering. To protect electronic components during use and allow for safe cleaning, detachable snap-button connectors are used between the conductive textile parts and control unit. Power is delivered from a rechargeable power bank via micro-USB and managed through an on-board power regulation module (5V and 3.3V) to match component voltage needs. This engineered integration of smart knitted textiles, control units, RGB LEDs, and micro-speakers creates an interactive textile system tailored for dementia care, providing intuitive interaction with immediate visual and audio feedback.

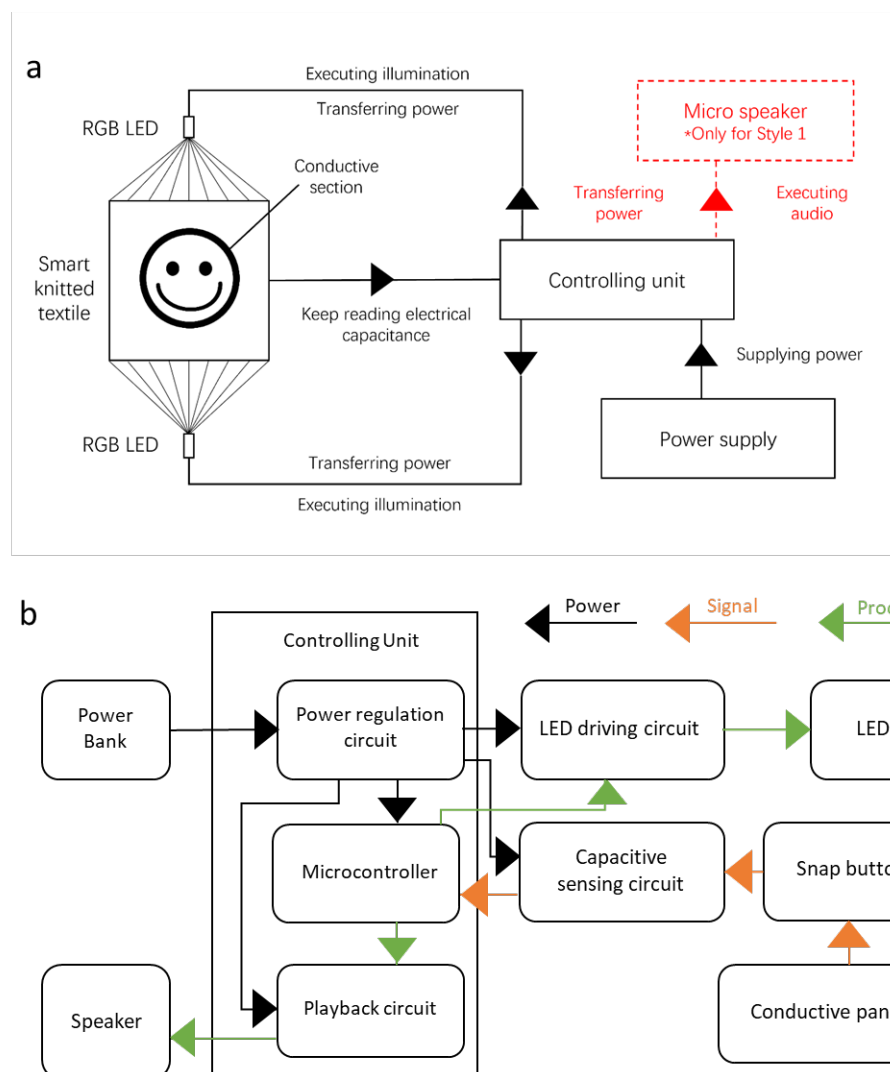


Figure 3. Design of intelligent knitted textiles and the interactive textile system. (a) Conceptual diagram of the interactive textile system. (b) Diagram of working process and components in the intelligent knitted textiles.

Development and Evaluation of the Multi-sensory Illuminated Cushions

Prototype development

Fabrication of smart knitted textiles. To create prototypes of four styles of MICs, the main parts were first fabricated—the knitted POF fabrics with capacitive sensing areas. The details of the materials used for the fabrication are listed in Table 2. The knit structure for realising the designs was based on a 3-colour doubled jacquard, while one of the colours was performing Terry stitches to create a different texture. Each of the three colours was knitted with one end of textile-based yarn Nm 2/34 55% extra-fine merino wool 45% cotton, which is machine washable for easy care. Polymethyl methacrylate POF with a diameter of 0.25 mm is chosen for development to create fine and soft POF textiles. After knitting the fabrics with the POFs, they were collected as bundles for connection with RGB LEDs. The knitted POF fabrics underwent laser engraving as an aftertreatment, enabling them to emit light on their surfaces. Two ends of silver-coated conductive filament 100D/36F 20% silver 80% nylon with an electrical conductivity of $\sim 7 \Omega/\text{m}$ were embedded in the conductive sections of the textiles to serve as a touch-reactive interface. The conductive filaments were knitted simultaneously with one of the colours in the 3-colour doubled jacquard.

The smart knitted textiles were all knitted on a computerised flat-bed knitting machine with a gauge of 14. The development on an industrial machine allows the knitting approach in this study to be reliable and scalable for production. The knitting data was programmed by computer-aided design (CAD) system and then inputted into the machine. As long as the appearance design of the cushion changes, the knitting data can be modified through the system to create the corresponding design, enabling diverse designs to accommodate the cultural differences of the users and even customised designs for personalised sensory experiences.

Table 2. Materials utilised for the fabrication of smart knitted textiles

Materials	Details
Polymethyl methacrylate (PMMA) POF	Fibre diameter: 0.25mm, Transmission Loss: 350 dB/km, Temperature range: -55 ~ +70°C
Silver-coated conductive filament	Count: 100D/36F, Composition: 20% Silver 80% Nylon, Electrical conductivity: $\sim 7 \Omega/\text{m}$
Textile-based yarn	Count: Nm 2/34, Composition: 55% Extrafine Merino Wool 45% Cotton, Care label: Machine wash cold or 30°C; Do not bleach; Dry flat; Iron at low heat

Construction of cushion covers and pillows. The smart knitted fabrics were pre-washed to stabilise their size after shrinkage, and softeners were also added to give the fabrics their softest tactility. On every conductive section, the back sides of the fabrics were attached with one side of a metal sew-on snap button for connecting with electronic components. The knitted fabrics are then sewn with satin fabrics made of 100% polyester to create four cushion covers, according to the designs. The cushion cover is a square with dimensions of 50 cm by 50 cm, with 5 cm wide satin borders on all four sides and a zipper opening. Pillows were specifically created to match the cushion covers and allow for seamless integration with the electric components. Four pillows were made from the same satin fabrics as their covers. The middles of their upper and bottom sides are sewn with a small opening, through which the wires and cables connecting the cushion covers and the electronic components pass. A pocket is sewn on the front side of each pillow for placing the power supply into it. The pillows have a zipper opening, and they are filled with hollow fibre filling made from 100% recycled polyester. Figure 4a demonstrates the appearance of the MICs.

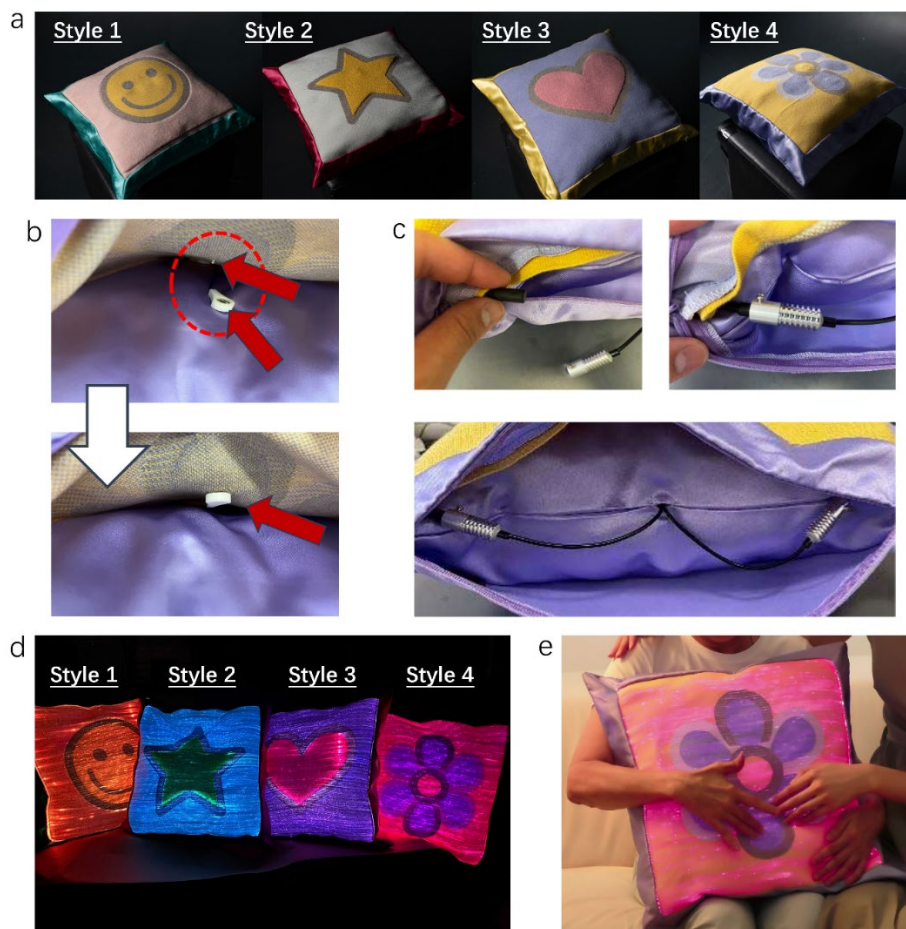


Figure 4. Prototypes for four styles of MIC (a) without illumination (b) Connection between smart knitted fabric and the controlling box (c) Connection between POF bundles of the smart knitted fabric and RGB LEDs (d) with illumination (e) under touch interaction

Integration with electronic components. The collaborative engineer designed and built a 3D-printed box for each cushion that incorporated all the electronic parts of the controlling unit. For style 1, the micro speaker was also hidden within the box. The controlling box, along with the relevant computer programs for each style, was positioned within the pillows and in between the fillings, ensuring that users would not encounter any discomfort from the rigid material. A cable with the receiving end of the micro-USB and a conductive wire was extended from the box and threaded through the small opening located on the upper side of the pillow. A power bank was positioned within the pocket on the pillow and linked to the cable to supply electrical power. The conductive wire's end was bonded to one side of a metal sew-on snap button. Figure 4b demonstrates its connection to the opposite side of the button on the smart knitted fabric, which enables the touch-reactive responses. In style 4, there are three wires for connecting with three different conductive sections of the fabric. Two RGB LEDs were connected into the controlling box and threaded through the small opening located at the bottom of the pillow. The POF bundles from the left and right edges of the smart knitted fabric were then attached to the LEDs (Figure 4c). The connections between the controlling box, power bank, RGB LEDs, those electronic components, and the cushion covers can be effortlessly detached. After removing the connections and taking out the pillows, the covers can be cleaned through laundering. The prototype development had been completed, resulting in the creation of four cushions featuring illuminated effects (Figure 4d) and interactive touch responses (Figure 4e).

Design refinement

A user trial was conducted in collaboration with the OT to enhance the design of MICs prior to clinical implementation. Through systematic evaluation of each cushion prototype, the OT identified several necessary improvements. The size of the pillows needed reduction, as they were deemed too large and cumbersome for comfortable handling by the older adults. Additionally, amplification of the volume of the soothing music response in style 1 was necessary to provide sufficient auditory stimulation. Improvements were also needed in the sensitivity of the conductive areas that trigger responses, as occasional unresponsiveness could potentially confuse users. Finally, while the MICs were initially programmed to automatically power off after 30 seconds of inactivity for safety reasons, it was suggested to eliminate this feature and instead allow users to manually control the power supply. These recommendations were incorporated into the revised prototypes before their application in the clinical setting.

Evaluation of clinical application by occupational therapists

The clinical application of the four developed MIC prototypes was further evaluated by OTs during multi-sensory stimulation sessions for residents at a later stage of dementia. An experimental design was adopted to compare MICs, and a commercially available vibration cushion was used as a control sample. The inclusion of a market-available sensory cushion allowed for a comparative analysis between MICs and a baseline product that is already in use in sensory therapy. This comparison was helpful for assessing the added value or potential benefits of MICs, particularly with respect to multisensory stimulation beyond vibration. Comparing the participants' engagement levels and individual responses in the sessions may provide valuable insights into the treatment effectiveness of the newly developed MICs and their potential to enhance multi-sensory treatments in dementia care.

Methods and materials

Participants. Convenience sampling was used to recruit residents with severe dementia from a Care and Attention Home between November 2023 and March 2024. The inclusion criteria were (1) aged ≥ 65 years, (2) formal medical diagnosis of dementia, and (3) Clinical Dementia Rating (CDR) score of 3. Residents with severe hearing loss, blindness, or an inability to follow one-step commands were excluded from the study.

Treatment. Each participant underwent four individual multi-sensory sessions: two treatment sessions utilising MICs and two control sessions using a conventional vibrating cushion. Participants were divided into two groups: group 1 received two treatment sessions in the first week and then two control sessions in the second week, and group 2 received two control sessions in the first week and then two treatment sessions in the second week. All multi-sensory sessions were structured identically, conducted at the same time of the day, and delivered by the same OT to ensure consistency across interventions. Each session began with a 5-minute greeting and gentle hand massage to establish rapport and relaxation, followed by the application of either the novel MICs (in the treatment sessions) or the vibrating cushion (in the control sessions).

Measures. Participants' engagement levels were assessed using the OME, with a higher score reflecting greater engagement. In addition to the quantitative assessment, qualitative observational data on participants' engagement was gathered through direct observation by another OT. They could provide valuable insights into how individual participants interacted with the sensory tools, capturing nuances in their responses, emotional states, and behavioural engagement throughout the sessions. This mixed-method evaluation was critical for building a comprehensive understanding of the effectiveness of MICs in promoting sensory experiences and interactions in dementia care.

Results and Discussion

The properties of the four MICs and one market sensory cushion are shown in Table 3. The scores of participants' engagement with the sensory tools during the treatment and control sessions are listed in Table 4, while Table 5 shows the attendance duration of both sessions. The discussion will focus on the sensory stimulation of the tools, the level of engagement, and overall user satisfaction, based on these objective data and the subjective data generated from the textual analysis of the participants' interactions with the tools through observation.

Table 3. Properties of the MICs and the market sensory cushion

	MIC style 1	MIC style 2	MIC style 3	MIC style 4	Market sensory cushion
					
Size	50 cm x 50 cm				30 cm x 30 cm
Sensory stimuli	Vision, touch, sound	Vision, touch			Movement
Interaction	Illuminate and play music when the conductive section is touched	Illuminate when the conductive section is touched		Illuminate in corresponding colours when any of three conductive sections is touched	Vibrate when the nodule is pressed
Textile texture	Satin fabric, wool fabric with Terry structures, wool fabric with plain structures				Leather effect vinyl fabric

Rigid material	No direct contact				Six nodules on the surface
Appearance	Motif ornamentation and contrasting colours				Plain with blue colour
Motif	Smile	Star	Heart	Flower	Nil
Easy care	Machine washable				Wipe clean only

Table 4. Scores of OME at treatment and control sessions

	mean $\pm$ standard deviation		Wilcoxon Signed Rank test (p- value)
	Treatment sessions	Control sessions	
Observational Measurement of Engagement (OME) #	4.73 $\pm$ 0.98	2.64 $\pm$ 1.58	<0.001

Mean scores of 3 items (engagement, active participation & attitude) (0-6)

Table 5. Attendance duration of treatment and control sessions

Attendance duration	Treatment session (n)		Control session (n)	
	1 st	2 nd	1 st	2 nd
<i>None</i>	0	0	3	3
<i>Small part</i>	0	0	5	4
<i>Less than half of the time</i>	1	2	1	2
<i>Half of the time</i>	0	1	4	2
<i>More than half of the time</i>	4	3	1	1
<i>Most of the time</i>	1	2	2	5
<i>All the time</i>	14	12	4	3

Sensory stimulation

The MICs offer a more comprehensive range of sensory stimulation compared to the conventional sensory cushion. While the conventional sensory cushion provides only one type of stimulation, the MICs deliver two to three distinct sensory stimuli depending on the user's interaction. All MIC styles are capable of delivering both vision and touch stimuli. In addition to the use of contrasting colours and motif ornamentation, the illuminated effects expand the range of visual stimuli that textiles can provide. Style 4 in particular offers dynamic illumination, with the colour of the light changing in response to different user interactions, thereby elevating the intensity of the visual stimulation. For touch stimulation, the MICs incorporate two to three contrasting textile textures, including soft and reassuring fabrics with

plain knit structures, rough and towel-like fabrics with Terry knit structures, and smooth and silky satin fabrics. These textures provide users with varied tactile experiences. Style 1 of the MICs also includes the ability to play soothing music as a sound stimulus for the user. When applied to elderly individuals with late-stage dementia, the MICs have the capacity to stimulate two to three senses at once, significantly enhancing the sensory experience compared to the single modality of the conventional sensory cushion. This multi-sensory approach is more effective, providing richer and more engaging experiences for the users. Furthermore, the availability of four different styles of MICs increases the flexibility for caregivers, allowing for personalised sensory experiences tailored to the preferences and needs of individual users.

Engagement level

A total of 20 participants (17 females) were recruited with a mean age of 87.35 ± 7.76 , and the mean years of education was 3.5 years. The baseline mean scores on the Montreal Cognitive Assessment in Hong Kong and the Chinese Cohen-Mansfield Inventory were 3.20 and 49.4, respectively. The analysis of engagement levels measured by the OME (Tables 4 and 5) revealed a statistically significant difference between treatment and control sessions. In the treatment sessions, an average of 90% of the participants demonstrated attentiveness for more than half of the duration or above. Conversely, only 40% of the participants exhibited similar levels of engagement during the control sessions.

Throughout the clinical observations, all participants exhibited positive responses to MICs during treatment sessions. They were observed using their hands to actively feel various textures and embrace cushions. Participants gazed at patterns and colour variations, with some displaying smiles and identifying. One individual spontaneously began to sing while engaging in MIC style 1. This behaviour may be interpreted as a physical-emotional response to auditory cues, where the musical stimulus triggered memory recall or emotional arousal, a known phenomenon in music therapy for dementia. The act of physically holding and hugging the cushion—facilitated by its compliant, ergonomic design—may have stimulated both comfort and exploratory behaviour (hand movement), fostering higher engagement. The ease of tactile activation also reduces the motor effort required, making it accessible and less cognitively taxing. In comparison, during the control sessions, most participants pressed the nodules when prompted and enjoyed the vibration effect. However, some of them remained unresponsive, and a few even threw the cushion away. The significantly higher engagement observed with MICs suggests not only increased attention but also deeper emotional resonance and active

participation from users. These findings imply that sensory tools embedded with intuitive, interactive technology can act as a bridge between users and their environment, helping reduce social withdrawal and passivity typically seen in advanced stages of dementia.

Overall user experience

A comparison of properties between the developed MICs and conventional sensory cushions reveals several advantages of the MICs in terms of comfort, usability, and adaptability for elderly people with dementia. The MICs are designed to prevent direct contact between users and rigid components, which is unusual for textile products. In contrast, the conventional sensory cushion features six rigid nodules on its surface that may create discomfort or awkward tactile experiences for users, diminishing overall acceptance. Moreover, the MICs are equipped with touch-reactive areas that can be easily activated through a simple touch on the surface, making them more accessible and adaptive to elderly individuals who may have physical limitations. Unlike the MICs, the conventional sensory cushion requires the user to press the rigid nodules to initiate vibration, an action that may be difficult for individuals with reduced strength or mobility. The difference in receptiveness can be partly explained by the physical discomfort or confusion caused by poorly integrated rigid elements in conventional designs. In contrast, the MICs' soft structure conforms to the body, offering sensory congruence between expected and actual tactile experiences. This congruence aids in emotional regulation and reduces agitation. Additionally, the spatial mapping of touch-reactive areas on the cushion follows natural hand-resting zones, improving accessibility and reducing frustration during use. By offering comfort-focused designs that require only natural, instinctive interaction, MICs achieve higher usability, encouraging longer and more meaningful engagement. This reinforces the importance of adapting interaction mechanisms to the declining motor and cognitive skills of late-stage dementia patients. In addition, the MICs offer greater variety by utilising industrial knitting machines integrated with CAD systems to produce smart knitted textiles, allowing for diverse and even customised design elements. Apart from appearance designs, such as colour and motif, the interactive responses, including the illuminated effect and audio, can also be modified to meet the specific needs and preferences of users. This variation fosters novelty for users, encouraging exploration and engagement while also supporting personalised care. The aforementioned advantages enhance overall user experience, making the MICs a more attractive and ideal option compared to conventional sensory cushions.

To support long-term use, the materials and electronics used in MICs were selected for their durability and ease of maintenance. These technical and ergonomic design decisions not only improve the durability of the product but also support its implementation in real-world care environments with practical demands such as hygiene management, caregiver usability, and repeat application. As such, MICs show strong potential for integration into mainstream care routines. The POFs and conductive yarns used in the knitted structure are known for repeated handling and mechanical flexibility, while detachable connectors allow for safe laundering of textile covers. The control system, encased in a protective 3D-printed housing, underwent stability testing to ensure proper functionality during normal routine handling. Future work will include long-term deployment studies in care settings to assess the reliability of the electronic system across repeated sessions, potential wear-and-tear of textile components, and user satisfaction over time. Ensuring long-term performance and resilience is crucial to integrating MICs as sustainable therapeutic tools in dementia care.

Limitations

Despite the promising results, several limitations and underlying assumptions should be noted regarding the current methods. First, the system assumes consistent environmental conditions such as lighting and acoustic levels, which can affect the visibility of illuminated feedback or the audibility of sound stimuli. Furthermore, the prototype designs were tailored within specific ergonomic ranges suited to frail older adults, but may require adjustment for individuals with extreme postural or sensory sensitivity.

From a methodological perspective, the study assumed that short-session engagement levels are indicative of longer-term interaction outcomes; however, long-term adaptability, novelty fatigue, and sensory overstimulation risks have not yet been evaluated comprehensively. A long-term testing phase needs to be continued.

Technical assumptions include the expectation that conductive yarns and POFs would maintain performance throughout repeated use and laundering. While durability testing was conducted at the prototype phase, real-world use may involve cleaning regimes, stretching, or inadvertent damage that could impact functionality. The detachment mechanism of electronic components was assumed to support hygiene, but repeated handling could also lead to mechanical wear

over time. These factors all indicate a need for ongoing design refinement and real-life validation.

Conclusion

This study demonstrates a collaborative project between textile design and occupational therapy, aimed at developing innovative sensory tools to enhance the well-being and interaction of elderly individuals with late-stage dementia. The project focusses on the co-design process and development of four multi-sensory illuminated cushions (MICs) using smart textile technology, each designed with distinct appearances and interactive responses. The MICs were able to provide multi-sensory stimulation, engaging the users' vision, touch, and sound senses, which offers more immersive and engaging experiences for users and allow carers to customise sensory experiences according to individual needs. The comparison between the MICs and the conventional sensory cushion revealed that the MICs offer a more diverse and personalised sensory experience. These innovations have the potential to significantly enhance the well-being of people with dementia, not only in Hong Kong but in care settings worldwide, by overcoming the drawbacks of traditional sensory tools.

The quantitative and qualitative findings from the collaborative evaluation by an occupational therapist suggest that the MICs may have a positive impact on engagement levels in the later stages of dementia during the multi-sensory sessions. While the results of this research are promising, there are some limitations in the clinical application, including the small sample size and the fact that participants were recruited from a single residential facility through convenience sampling. Because of the infection control measures in the care unit, randomisation was not possible in the allocation of participants to groups 1 or 2, and the OME evaluator was not blinded to the study. Despite these limitations, the experimental design provides valuable information for further evaluation of the treatment effectiveness of MICs after the user trial.

Further studies with larger sample sizes and extended observation periods are recommended to validate the long-term treatment effectiveness of MICs in different care settings. The MICs also present future potential as part of remote care and telehealth strategies, where low-effort smart textiles can passively promote mental stimulation even in understaffed environments or at home. Moreover, the design approach detailed in this study offers a framework for the

development of similar textile-based intervention tools for related conditions such as Alzheimer's disease, sensory impairment, or rehabilitation care. Nonetheless, the findings highlight the importance of incorporating intelligent textile technology into dementia care tools, underscoring its potential to transform the future of non-pharmacological interventions in enhancing the quality of life for elderly individuals with dementia.

Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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