“Blue tastes like salt. It just does”: Exploring generational differences in the construction of cross-sensory metaphors

Tegan Roberts-Morgan
School of Computer Science
University of Bristol
Bristol, United Kingdom
tegan.roberts-morgan@bristol.ac.uk

Brooke Morris
School of Computer Science
University of Bristol
Bristol, United Kingdom
brooke.morris@bristol.ac.uk

Min Susan Li
School of Computer Science
University of Bristol
Bristol, United Kingdom
min.li@bristol.ac.uk

Amy Ingold
School of Computer Science
University of Bristol
Bristol, United Kingdom
amy.ingold@bristol.ac.uk

Matthew Horton
ChiCI Lab
University of Central Lancashire
Preston, United Kingdom
mplhorton@uclan.ac.uk

Janet Read
ChiCI Lab, University of Central Lancashire
Preston, United Kingdom
jcread@uclan.ac.uk

Dan Bennett
Bristol Interaction Group
University of Bristol
Bristol, Bristol, United Kingdom
db15237@bristol.ac.uk

Oussama Metatla
School of Computer Science
University of Bristol
Bristol, United Kingdom
o.metatla@bristol.ac.uk

Abstract

Metaphors improve communication between children and adults, which can be challenging due to differences in experiences. Cross-sensory metaphors convey qualities associated with one sense using terms from another, e.g. a “sharp smell” and could thus improve generational communication by bridging differences in sensory cognition. We observed children (8-11yrs, n=65), young adults (18-24yrs, n=51) and older adults (60-85yrs, n=38) playing Sense-O-Nary, a variation of Pictionary where players construct and interpret cross-sensory metaphors, and analysed differences in metaphor type, degree of elaboration, and association strategies. We found that children relied on “familiar experiences” for metaphor construction, while adults used more diverse association strategies. Degree of elaboration was consistent across ages for tactile and visual stimuli but differed for olfactory stimuli. All groups used “active” metaphors most commonly, but children showed more use of “implicit”, “similes”, and “personification”. We present designs that demonstrate how these characterisations could be leveraged to improve intergenerational communication.

CCS Concepts

• **Human-centered computing → Empirical studies in HCI**.

Keywords

Crossmodal Interaction, Metaphors, Intergenerational, Cross-Sensory, Communication

IDC '25, Reykjavik, Iceland

ACM ISBN 979-8-4007-1473-3/25/06
https://doi.org/10.1145/3713043.3727060

ACM Reference Format:
Tegan Roberts-Morgan, Brooke Morris, Min Susan Li, Amy Ingold, Matthew Horton, Janet Read, Dan Bennett, and Oussama Metatla. 2025. “Blue tastes like salt. It just does”: Exploring generational differences in the construction of cross-sensory metaphors. In *Interaction Design and Children (IDC '25), June 23–26, 2025, Reykjavik, Iceland*. ACM, New York, NY, USA, 16 pages. https://doi.org/10.1145/3713043.3727060

1 Introduction

Cross-sensory [1] metaphors describe experiences or objects by borrowing language from a different sensory modality; for example disappointments leave us feeling “blue” and powerful flavours can be “loud”. Recent work has emphasised the need to develop our understanding of how cross-sensory experiences can be shared [69]. This understanding would be useful when considering how people communicate experience with each other, and how this can be improved [31, 55].

Effective communication remains a significant challenge for many groups[1, 2, 73, 76]. Children, in particular, often face difficulties due to their limited vocabularies and their developing understanding of grammar and syntax, which are essential for expressing complex ideas[17, 59]. These challenges are exacerbated in intergenerational communication, where children must convey their experiences - such as pain, emotions, and general well-being - to older generations. Intergenerational communication can be hindered by cognitive and sensory differences between age groups [42, 49]. To address these issues, technology has been developed to support and aid communication. [58, 89], with a particular focus on using tangible devices in interactive experiences [87, 90]. However,

[1]We use the term “cross-sensory” as opposed to multisensory or multimodal to emphasise the transfer of information between individual senses. Whereas multimodal or multisensory might suggest a more generalised merging of sensory outputs, the “cross-sensory” distinction is grounded in crossmodal perception and cognition [68] and is therefore more aligned with what we are trying to explore here.

there has been little focus on how language use varies with age in the context of technologies that rely on multiple senses. This gap underscores the need for further research into designing tools that effectively bridge linguistic and sensory differences across generations.

In the fields of HCI and cognitive sciences, there are well-established databases of standardised stimuli designed to elicit specific emotional reactions. However, these stimuli are predominantly unimodal, focusing on individual sensory modalities such as auditory [10], visual [45], or haptic [56]. These unimodal approaches have been instrumental in advancing our understanding of sensory-emotional relationships, but have limitations when addressing the interplay between sensory modalities. Similarly, research on sensory vocabularies has been primarily modality-specific, with efforts aimed at supporting designers in describing and communicating sensory experiences within a single sensory domain, such as thermal [32] or haptic experiences [55]. While these vocabularies have enhanced the design of sensory interactions, they fall short of encompassing the complexities of cross-sensory experiences. More recent efforts have expanded to multimodal emotional stimuli [37], marking an important step toward integrating multiple sensory inputs. However, these efforts have yet to explore concurrent cross-sensory presentations, where information is transferred or shared across modalities. This represents a critical gap, as cross-sensory interactions are central to how humans perceive and interpret complex sensory environments. Roberts-Morgan et al. [60] have begun to address this gap by studying how children create cross-sensory metaphors through play. Their findings revealed that children tend not to rely on personal experiences when forming these metaphors, a behaviour they speculated may differ from older participants. While this study underscores the importance of cross-sensory metaphors and highlights potential age-related differences, it also raises significant questions. Specifically, there remains a lack of understanding of how individuals across different age groups create and interpret cross-sensory metaphors and how this may influence the design of interactive technology. Investigating these differences is crucial for advancing the design of cross-sensory systems and understanding the role of age in shaping sensory-emotional experiences.

To address this gap, we conducted an exploratory study utilising Sense-O-Nary [60], a game specifically designed to foster an environment where cross-sensory metaphors can be supported and actively created. The study included participants from three distinct age groups: children (8–11 years, n = 65), young adults (18–24 years, n = 51), and older adults (60–85 years, n = 38). The research aimed to address two key questions: 1. How do different age groups create cross-sensory metaphors? 2. How can we leverage this in the design of intergenerational communication?

The contributions of this paper are as follows: First, we identify the association strategies employed to create cross-sensory metaphors, the types of metaphors generated, and the variations in how different age groups elaborated on these metaphors. For instance, children predominantly relied on associations with common, everyday objects, whereas older participants used a more diverse range of associations, including evaluations and personal stories. While there was little difference across age groups in how metaphors for tactile and visual stimuli were elaborated, we observed key differences for olfactory stimuli. Children tended to use longer, more descriptive narratives, whereas older adults were comparatively concise. Based on these findings, we provide recommendations to inform the design of technologies aimed at enhancing intergenerational communication. Additionally, we propose design examples that address key scenarios, including doctor-patient, teacher-student, and parent-child interactions.

2 Background

2.1 Intergenerational Communication

Communication is a critical developmental skill, crucial to the ability to share knowledge, express needs, and build meaningful social connections [53, 85]. Communication abilities develop over time alongside linguistic [40, 59] and social skills [29, 41]. This leaves children with smaller vocabularies than adults and less developed understandings of the grammar and syntax needed to express complex ideas [59]. Children also lack breadth of experience, making it harder to relate to or understand abstract concepts [21]. Taken together, this can lead to greater struggles to communicate [28]. Such factors can lead to challenges around *intergenerational communication* — the exchange of information, ideas and values between people from different age groups [88]. Communication between people of different ages has been shown to reduce age-related stereotypes, improve social support systems and enhance the well-being of both older and younger generations. [39]. However, communication between different age groups is prone to miscommunication [2], due to language differences [77], age-based discrimination [54, 65], culture [76, 81] and differing familiarity with technologies [57].

To help counteract these barriers, technologies have been developed to support intergenerational communication [58, 89]. Many of these technologies focus on using tangible devices, which create interactive experiences for users across multiple age groups [87, 90]. Wallbaum et al. created StoryBox [87], a tangible device that allows sharing of photos, tangible artefacts, and audio recordings. They found that by using both digital and non-digital elements, their devices were accessible and bridged the technology gap. Axtell et al. [7] explored best practices for designing intergenerational technology. Addressing how young children imagine communication with distant family members, they highlight a preference among children for the use of both emotional and sensory experiences, and creative and playful forms of interaction.

2.2 Cross-sensory Interaction

Cross-sensory technology refers to devices that combine multiple sensory modalities to create more immersive and intuitive user experiences. Such technology is increasingly common and the range of senses included is growing [e.g. 32, 47, 55]; often with the aim of designing technologies which can more effectively express affective experiences [34] and help users communicate with one another [65].

The effective design of cross-sensory systems relies on an understanding of *cross-sensory correspondences.* These are preferential associations between particular sensory features across different senses [46, 69, 71]. They play a crucial role in enhancing communication, since they allow for the reinforcement of information across multiple senses, making information more memorable [18, 64]. They also offer potential in understanding how users with different sensory abilities can share technologies, interact together, and communicate with each other [51]. In HCI, much work on cross-sensory correspondences has been based on the Bouba-Kiki effect [e.g. 46, 51]. This is a psychological phenomenon based on sound-shape correspondences, which serves to shed light on people’s tendency to form associations across senses. A large body of work finds that when people are asked to choose names for rounded and sharp, jagged shapes, people tend to associate rounded shapes with the word “Bouba” and a sharp shapes with the word “Kiki”. This effect is remarkably consistent, and has been replicated with diverse participants across different cultures [16, 24] and age groups [36, 48].

Researchers have used studies of this effect as a foundation to understand associations between senses and emotions. Lin et al. [46] investigated touch-affect associations, finding cross-sensory correspondences between an object’s features and both colours, and between the same features and perceptions of emotion. Feng et al. [31] extended this research to understand similar correspondences in shape-changing stimuli, finding that touch-affect associations are influenced by both the size and the frequency of the shape-change and may be modality-dependent. Metatla et al. [51], explored how 14 children aged 10 to 17 specifically perceive correspondences between scents, shapes and emotions. They found that angular shapes are associated with the “kiki” sound, lemon scents and aroused emotions, while round shapes are associated with the “bouba” sound, vanilla scents, and calming emotions. One line of research in this area has focused on language, addressing users’ *association strategies* [e.g. 46, 51, 60] — the strategies users draw upon to draw associations across senses. Attention to these association strategies can help us to understand how users establish connections, and the effectiveness of different communication strategies for particular senses.

However, prior research has not looked into the difference that age plays in the language used during cross-sensory experiences and how cross-sensory experiences are affected by ageing. There is evidence that the decline in sensory function with age can lead to changes in how experiences across different senses are integrated [26] This comes alongside changes in emotional perception [62], experience [91], and regulation [82], suggesting that sensory-affective correspondences may also change with age. This suggests both a need to support the communication of sensory and emotional experiences between different age groups, and a need to understand differences in perception and cognition which may impact on this communication.

2.3 Metaphors

Metaphors are figures of speech that describe one thing by referring to another thing which is considered to have some similar characteristics [13]. Metaphors are ubiquitous in everyday language use. They help us to communicate effectively by connecting unfamiliar objects and ideas by reference to things that are already familiar, thereby supporting efficient and accurate communication and mutual understanding [38]. In this paper, we focus on cross-sensory metaphors: describing something using language from senses not typically associated with that something [60, 70]. Examples include describing a taste as “sharp”, or a shirt as “loud”. Cross-sensory metaphors leverage our natural ability to create connections and correspondences between different sensory experiences, in order to make communication more vivid and impactful, allowing for better understanding [70].

Researchers in HCI have proposed that understanding cross-sensory metaphors could inform the design of interfaces that enhance communication and emotional expression. To explore this phenomenon, Roberts-Morgan et al. [60] recently developed a game to study the creation and use of cross-sensory metaphors. Their findings revealed that children employed a narrower range of cross-sensory association strategies compared to older participants in related studies. These results suggest the potential for age-related differences in metaphor use, raising important questions about how technologies relying on cross-sensory experiences might be interpreted differently across age groups. Despite this, no research to date has systematically investigated these differences.

2.3.1 Age and Metaphors. Metaphor comprehension evolves as we age, improving from age 6 [67]. By age 8, children begin creating metaphors, and by age 9 to 11, they can effectively paraphrase and fully understand them [19, 86]. Improvements in comprehension continue through adolescence, with clear progress between ages 11, 15, and 21, related to the development of executive functions [15]. There is evidence that changes in metaphor processing continue through adulthood, with brain imaging studies showing differences in localisation of activity between young adults and those over 60 [50]. Such differences in metaphor use between age groups may pose challenges for intergenerational communication. We suggest they also point to opportunities for technologies to help scaffold communication and self-expression in age-appropriate ways. However, to date, there is a lack of work on metaphor use across age group,s which could guide the design of such technologies.

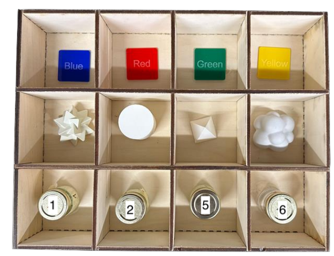
2.3.2 Type of Metaphors. Much modern work on metaphor is influenced by the cognitive linguistics tradition, initiated by Lakoff and Johnson [44]. Lakoff and Johnson identify three broad kinds of metaphor: structural, orientational and ontological. Of these, ontological metaphors are particularly relevant to the analysis of how people convey entities using sensory and emotional language, insofar as they offer “ways of viewing events, activities, emotions, ideas, etc., as entities and substances”. As such, they are common in everyday speech:“so natural and persuasive in our thought that they are usually taken as self-evident, direct descriptions of mental phenomena” [44, chapter 6]. This resonates with the seemingly non-arbitrary association across sensory modalities that are grounded in cross-sensory cognition [69].

There are many ways of categorising ontological metaphors, depending on the context and goals of analysis. One of the most commonly recognised kinds of ontological metaphor is *personification*, which connects human qualities to things which are not human [44]. A more specific example of a metaphor typology relevant to the work in this paper can be found in Tehseem and Khan’s work on metaphors in children’s literature [79]. They identify four kinds:"*active*" (metaphors that directly state the comparison between two things e.g "you are my sunshine"),"*dead*" (metaphors so familiar that they are no longer recognised as metaphors — e.g. "head of the table"),"*extended*" (a metaphor developed at length over a paragraph or speech) and"*implicit*" (metaphors where the comparison is suggested but not directly stated e.g "Ready to hit the sack"). Finally, Lakoff and Johnson note the commonness of "*mixed*" metaphors, where two or more phenomena, entities, or concepts are invoked in a way which may not be consistent [44, chapter 16]. For example the sentence "We are *flying* through a *sea* of success", mixes metaphors for flight and swimming.

2.3.3 Sense Vocabularies. Previous work has addressed metaphor and language in sensory technologies. Some research in this area has created sensory vocabularies focused on individual senses [32, 55]: Feng et al. [32], for example, described a framework for describing and conceptualising thermal and affective experiences for design, based in an analysis of Chinese poetry. In this and subsequent work [33], they demonstrate how such understandings of sensory language can support the creation of more immersive and contextually relevant user experiences. Meanwhile Obrist et al. offer a framework for understanding how tactile sensation and haptic technologies can be used in user interfaces to enrich interaction [55]. Such research efforts support understanding of sensory experience which can enrich technical aspects of designing for sensory experience, communication and expression. However, as Feng et al. note, most such work has focused on individual senses, neglecting how senses function together [32]. Roberts-Morgan et al. [60] began to address the vocabulary surrounding multiple senses. They developed a game-task to study how children create cross-sensory metaphors. Their findings suggest that there may be a difference between how children and people of different age groups create cross-sensory metaphors, as children used familiar items as opposed to previous work that suggested adults relied on personal connections to create cross-sensory metaphors. This suggests that there is a need to understand how different age groups create these cross-sensory metaphors and why the techniques used may differ. The majority of these vocabularies focus on a single modality and there needs to be further research on how expression and communication is realised across multiple sensory modalities.

(a) The circular box, which has 6 compartments, each containing one of the sensory objects.

(b) The sense spinner, has various senses used to give expression modalities.



(c) The selection box, contains all of the sensory objects that could be described.

Figure 1: The three different components to the Sense-O-Nary game [60]

3 Study

In this study, we aim to answer two questions: How do people of different ages create cross-sensory metaphors, and how can this be used to inform the design of intergenerational communication? We look at how three age groups, children, young adults, and older adults, communicate cross-sensory experiences to peers of the same age, using the Sense-O-Nary game [60]. We then take the metaphors created from this game and code them based on the *cross-sensory association strategies* used to generate them, and characterise them in terms of *type of metaphor* and *degree of elaboration.*

3.1 Participants

We recruited three age groups for this study: children (n = 65, ages 8–11), young adults (n = 51, ages 18–24), and older adults (n = 38, ages 60–85). These age groups were selected based on prior research highlighting differences in metaphor processing between 20- and 60-year-olds [72] and evidence that children begin to fully comprehend metaphors around age 8 [19, 67, 86]. Participants engaged in the study exclusively with peers from the same age group. Recruitment took place during age-specific research events where participants were familiar with one another. Children and young adults participated in university-sponsored events. Children, grouped by school classes (6–8 participants), took part in school or lab-based activities, while young adults (groups of 4–6) participated within university classes. Older adults, grouped in six, were recruited through a charity's social groups and participated in sessions held at local cafes, with all group members knowing one another beforehand.

3.2 Sense-O-Nary Game Components

We used the Sense-O-Nary game, a variation of Pictionary where players construct and interpret cross-sensory metaphors [60]. The game has three components; A circular box, which has 6 compartments, each containing one sensory item; a sense spinner, which has various senses used to indicate expression modalities; and a selection box, containing all sensory objects in the game .

3.2.1 Sensory Items. Figure 2 shows the 12 different items which players describe. They include 1) four 3D-printed blocks spray painted red, green, blue and yellow, engraved with the names of the colours, 2) four jars each containing cotton wool and a few drops of scented essential oil, and 3) four 3D-printed shapes spray painted white. The shapes include a pyramid shape a cylinder shape, a sharp and pointy shape called Kiki and a round, bubbly shape called Bouba. The choice of objects was based on work by Usnadze [83], demonstrated cross-sensory correspondences between shapes, colours, scents and the sound-words "Bouba" and "Kiki", using items that reflect previous work in HCI [31, 46, 51]

(a) The 3D printed squares that represented one of the four colours. **(b) The four scent jars. There is cotton wool and essential oil in the jar.** **(c) Four 3D-printed shapes sprayed white, and sanded to smooth any pointy edges.**

Figure 2: The 12 different sensory items.

3.3 Sense-O-Nary Game Play & Procedure

We introduced the game Sense-O-Nary to each group with a 10-minute demonstration. Sense-O-Nary encourages players to create cross-sensory metaphors. The game involves two teams: one uses a circular box with a selection spinner on top of it (Figure 1a) and a separate sense spinner (Figure 1b), while the other team uses a rectangular box containing various items (Figure 1c). The first team spins the selection spinner to choose a sensory item from the box, and then uses the sense spinner to determine the modality for describing it (from the list: sight, smell, sound, taste, touch, emotion). for example, they may get the colour red from the circular box, and the expression modality "taste" from the sense spinner, in which case they need to describe the colour red in terms of taste for the second team to guess. If necessary, the first team can provide additional metaphors to assist the guessing team. The second-guessing team then consult with one another and pick the corresponding item from the rectangular box available to them.

We explained the game and demonstrated how to play it, then the participants play a few rounds to familiarise themselves with the items. We allowed participants to spend as much time as they wanted to play the game. Children and young adults played the game for roughly 15 minutes and the older adults took around 20 minutes. Researchers were present throughout the game to guide participants if needed.

3.4 Data Collection and Analysis

Each group was video- and audio-recorded using a GoPro. To maintain anonymity, recordings excluded participants' faces and focused on their hands to analyse interactions and gestural communication. The first author manually transcribed 13 hours and 8 minutes of video recordings and coded the transcripts, focusing on game parameters and metaphor use. For each game round, we recorded the sensory item described, the expression modality, the metaphors used, and the item guessed. When initial guesses were incorrect, players often clarified and guessed again; in these instances, additional metaphors and guesses were coded for the same round. Building on prior work, we conducted deductive coding to identify association strategies used to construct the metaphors [46, 51, 60] and the types of metaphors [44, 79]. Space was also left for inductive coding, which identified varying degrees of elaboration. The coding was completed by the first author and validated through iterative discussions with other authors. Table 1 presents the frequency with which each item was described using a particular sensory modality. Due to the random nature of the game, some combinations were not played (e.g., vanilla was never described using emotion, and Bouba was never described using smell). As the game served as an exploratory tool rather than a basis for strict quantitative analysis, our primary focus was on ensuring participants remained engaged and enjoyed the experience, recognising the inherent challenge of creating cross-sensory metaphors.

Item	Smell	Sight	Touch	Taste	Emotion	Sound	Total
Rose	x	3	5	4	3	5	20
Vanilla	x	4	4	4	0	3	15
Lemon	x	2	4	3	4	5	18
Peppermint	x	2	3	3	3	4	15
Green	3	x	8	7	1	2	21
Red	5	x	4	1	1	6	17
Yellow	2	x	1	1	6	2	12
Blue	4	x	5	2	6	3	20
Bouba	0	3	x	2	2	3	10
Cylinder	6	1	x	2	1	2	12
Kiki	4	3	x	6	4	1	18
Pyramid	2	3	x	4	1	2	12
Total	26	21	34	39	32	38	190

Table 1: Number of times each item was described using a sense. The 'x' marks the associated sense, so it wasn't used for description.

3.4.1 Association Strategies. After this initial coding, we allocated an association strategy to each metaphor. Association strategies describe how a connection is made between two different concepts [46, 51, 60]; they enable us to understand how a connection was created and the reasoning behind the decision-making process. We drew on categories used in previous work on cross-sensory correspondences [46, 51] and adapted them for our purpose. The association strategies we used, along with descriptions and examples are described in Table 2.

In our study, we considered not only the metaphors provided by participants but also the accompanying justifications for their use of a particular idea. This approach influenced the categorisation of certain metaphors. For example, if the colour green was described as tasting like "a plant," analysing the metaphor in isolation would categorise it as a *familiar experience*. However, if the justification provided was "green reminds me of a plant I used to eat during my childhood," the metaphor would instead be categorised under the *personal connection* strategy.

Strategy	Description	Example
Embodied Action	Gesturing with hand or body to help a description.	"It feels like this," then stroking the floor.
Grasping for Another Sense	Words from a sensory modality other than that selected for the round.	"This tastes strong" (e.g., referring to a shape).
Personal Connection	They use a specific, personal story to describe the item.	"This sounds like when you're at Ikea and you get a receipt and that sound when it comes out."
Sensory Features	Features of a sense have been used to describe the item.	"Sharp and smooth."
Valence	Use of terms to denote positive and/or negative qualities.	"This tastes horrible."
Vocalisation	A sound/noise is made instead of using words to describe an item.	"This sounds like Krrrrr and tsssss."
Familiar Experience	A description was created by relating the item to a common object, emotion, texture, etc.	"This smells like a banana smoothie."

Table 2: The eight different association strategies and their descriptions. Adapted from [60].

Type of Metaphor	Description	Example
Active	A metaphor that directly states the comparison between two things, without using "like" or "as".	"It is freshly cut grass."
Implicit	A metaphor where the comparison is suggested but not directly stated.	"It's really good in the summer and you lie on it."
Mixed	A combination of two or more incompatible metaphors that creates confusion or humor.	"It's angry and happy."
Simile	A comparison using "like" or "as" to show similarities between two different things.	"Tastes like a point."
Personification	A comparison using a human quality or characteristic for something non-human.	"I enjoy touching it, it hurts me."
Dead	A metaphor so familiar it is no longer recognized as a metaphor.	"Head of the table" (none in corpus).
Extended	A metaphor developed consistently and at length, over several sentences.	Shakespeare's "world as stage" metaphor (none in corpus).

Table 3: The six types of metaphors, their descriptions [44, 79], and an example from our study.

3.4.2 Type of Metaphors. We also coded the types of metaphors used. For this we drew seven categories found in Lakoff and Johnson [44] and Tehseem and Khan [79]: "active", "implicit", "dead", "extended", "simile", "mixed" and "personification". The rationale for selecting these categories is described in subsubsection 2.3.2, and we provide a table of definitions, together with examples from the corpus in Table 3). In our sample we found no "dead" or "extended" metaphors. One description was not categorised since it did not make use of metaphor but related to linguistic limitations ("I don't know how to describe that in English").

3.4.3 Degree of Elaboration. During coding, we observed that players elaborated their metaphors to different degrees — using simpler or more elaborate forms of expression. We identified three degrees of elaboration: simple, multiple and narrated. We coded *simple* when a single word or short phrase was used to describe an idea (e.g., "Rage."). We coded *multiple* when multiple words or short phrases capturing multiple qualities often via multiple metaphors, (e.g., "It's salty, chlorine, expired ice cream, mouldy cheese.".) Finally, we coded *narrated* where participants communicated via stories, scenarios, or rich imagery (e.g., "When you don't want to speak to anyone, and you're really aggressive").

4 Findings

4.1 Association Strategies

4.1.1 Sight. The *familiar experience* strategy was the most commonly used across all age groups when sight was the expression modality (children: 50%, young adults: 46.67%, older adults: 45.45%). Examples include describing a rose as "beautiful and green," vanilla as "brown," and the kiki shape as resembling a "thistle." The *personal connection* strategy was notably prevalent among young adults (40%), such as describing peppermint as "green, like After Eight mints you have at Christmas," whereas children did not use this strategy at all. The *sensory feature* strategy was the second most common approach across all age groups. Children used it in 25% of cases, with descriptions such as the kiki shape being "pointy." Young adults (26.67%) provided more detailed descriptions, such as a rose being "round, spherical, spiky, sharp, and shiny," while older adults (27.27%) offered descriptions like the bouba shape being "bubbly." Additionally, children frequently employed the *grasping for another sense* strategy (25%), offering associations such as connecting the lemon scent to "orange juice after you have brushed your teeth."

4.1.2 Smell. All age groups predominantly relied on *familiar experience* when using smell as an expression modality. Children

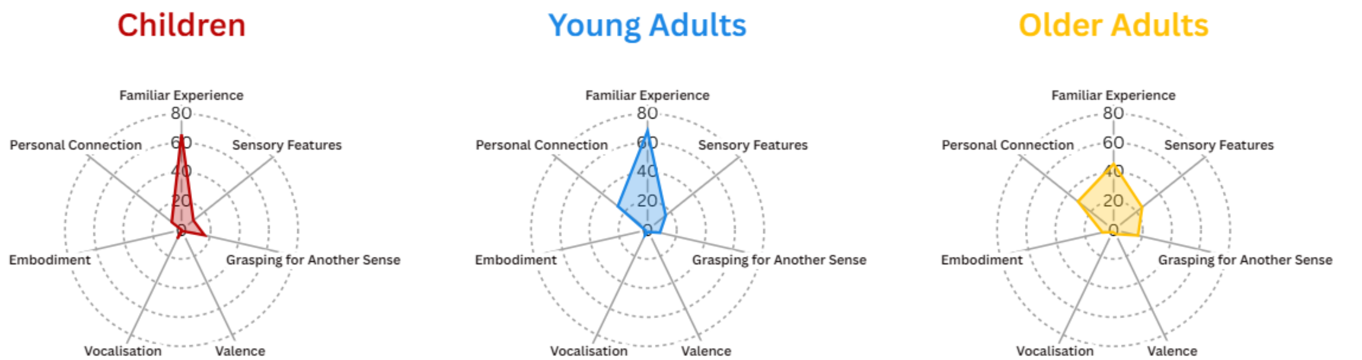


Figure 3: The *association strategies* most commonly employed by each age group, irrespective of the item being described.

	Age Group	Familiar Experience	Sensory Features	Personal Connection	Valence	Vocalisation	Grasping for Another Sense	Embodiment
Emotion	Children	43.75%	18.75%	18.75%	0.00%	6.25%	12.50%	0.00%
	Young Adults	57.14%	9.52%	19.05%	4.76%	0.00%	9.52%	0.00%
	Older Adults	16.67%	41.67%	25.00%	8.33%	0.00%	8.33%	0.00%
Sight	Children	50.00%	25.00%	0.00%	0.00%	0.00%	25.00%	0.00%
	Young Adults	46.67%	26.67%	26.67%	0.00%	0.00%	0.00%	0.00%
	Older Adults	45.45%	27.27%	18.18%	0.00%	0.00%	9.09%	0.00%
Smell	Children	80.00%	0.00%	0.00%	0.00%	0.00%	20.00%	0.00%
	Young Adults	70.00%	20.00%	10.00%	0.00%	0.00%	0.00%	0.00%
	Older Adults	60.00%	0.00%	30.00%	0.00%	0.00%	10.00%	0.00%
Sound	Children	61.54%	3.85%	7.69%	0.00%	19.23%	7.69%	0.00%
	Young Adults	9.09%	0.00%	45.45%	0.00%	27.27%	18.18%	0.00%
	Older Adults	21.05%	10.53%	31.58%	0.00%	0.00%	21.05%	15.79%
Taste	Children	75.00%	0.00%	5.00%	0.00%	0.00%	20.00%	0.00%
	Young Adults	71.43%	4.76%	19.05%	0.00%	0.00%	4.76%	0.00%
	Older Adults	30.77%	0.00%	38.46%	7.69%	7.69%	15.38%	0.00%
Touch	Children	51.72%	17.24%	10.34%	3.45%	3.45%	13.79%	0.00%
	Young Adults	55.56%	22.22%	0.00%	0.00%	0.00%	11.11%	11.11%
	Older Adults	42.11%	31.58%	5.26%	0.00%	0.00%	10.53%	10.53%

Table 4: Comparison of the Association Strategies used by each age group based on the expression modalities. The strategy that was used the most for each expression modality and for each age is highlighted in green.

used this strategy 80% of the time, offering descriptions like yellow smelling "like a banana smoothie." Both young adults and older adults used *familiar experience* 60% of the time, with young adults describing a cylinder as smelling like "wood, soap, and a candle," and older adults associating red with "strawberries and beetroot." Children employed *grasping for another sense* for the remaining 20%, such as describing a cylinder as smelling like "something that can roll." Young adults used *sensory feature* 20% of the time, offering descriptions like a pyramid smelling "spicy." Older adults, however, incorporated *personal connection* 30% of the time, such as describing the kiki shape as smelling "as clean as the driven snow," while referencing a book the group had recently discussed.

4.1.3 Sound. Children were the only group to primarily use *familiar experience* (61.54%) to describe items using sound, offering examples like red sounding like "screaming and echoing." In contrast, young adults (45.45%) and older adults (31.58%) relied more on *personal connection*, with young adults describing a rose as sounding like "a receipt printing at Ikea" and red as sounding like "crackling fire." Children employed all strategies except *Embodiment*, whereas older adults used *Embodiment* (15.79%) to describe a cylinder as a "didgeridoo," mimicking the act of playing it with their hands.

4.1.4 Taste. Both children (75%) and young adults (71.43%) primarily used *familiar experience* when taste was the expression modality, with children describing vanilla as tasting like "Dr Pepper" and young adults associating green with "vegetables." Older adults, however, relied most on *personal connection* (38.46%). Children also used *grasping for another sense* (20%) to describe a pyramid tasting "smooth and sharp on the edges." Young adults incorporated *personal connection* (19.05%) in metaphors, such as peppermint reminding them of "mints you have after going to a restaurant." Older adults employed a broader range of strategies, using all except *Embodiment* and *sensory feature*.

4.1.5 Touch. For touch, all age groups predominantly used *familiar experience* as the primary strategy. Young adults did not use *personal* *connection*, *valence*, or *vocalisation*, but employed *sensory feature* (22.22%) to describe vanilla as "smooth" and *grasping for another sense* (11.11%) with examples like rose feeling "dizzy." They also used *Embodiment* (11.11%), describing rose as "soft" while moving their hands in a smooth, slow motion. Similarly, older adults employed *Embodiment* (10.53%), describing red as "burning" and mimicking the action of rubbing their hands together.

4.1.6 *Emotion.*

When the expression modality was emotion, the *familiar experience* strategy (see Table 4) was the most commonly used across all age groups, particularly among children (43.75%) and young adults (57.14%), who frequently used cross-sensory metaphors such as describing the kiki shape as "angry." Older adults, however, relied more on *sensory feature* (41.67%), focusing on specific sensory characteristics. Young adults also employed *personal connection* (19.05%), while older adults used this strategy even more frequently (25%), with examples like associating yellow with "sorrow, like when I went to a funeral," referencing a recent event involving yellow flowers. Children used both *sensory feature* and *personal connection* (18.75% each), offering metaphors such as the bouba shape being "a happy thing" and the kiki shape representing "when you don't want to speak to anyone and you're aggressive."

4.2 Types of Metaphors Created

Figure 4 shows the percentage distribution of metaphor types used by each age group, irrespective of the stimuli described or the expression modality. Active metaphors are the most commonly used type across all age groups, with older adults employing them most frequently, closely followed by young adults. While children also favour active metaphors, their usage is notably lower compared to the other groups. Interestingly, children demonstrate a greater preference for personification and similes than the older age groups, while relying less on active metaphors. Young adults show a relatively balanced use of other metaphor types, with mixed metaphors being particularly prominent compared to both older adults and children. However, their use of personification and similes is less frequent than in the other groups. Older adults stand out with the highest reliance on active metaphors, while their use of other metaphor types remains minimal.

4.3 Degree of Elaboration Used

Figure 5 highlights the similarities and differences in the degree of elaboration used to create metaphors based on the stimuli participants were asked to describe. Metaphors describing shapes showed a consistent distribution of elaboration across all age groups. Similarly, metaphors for colours demonstrated comparable degrees of elaboration, except for young adults, who tended to use more multiple-degree elaboration, and older adults, who tended to use less. In contrast, metaphors describing scents revealed notable age-related differences. Children frequently employed a higher degree of elaboration, older adults leaned towards a lower degree, and young adults most often used a multiple-degree approach.

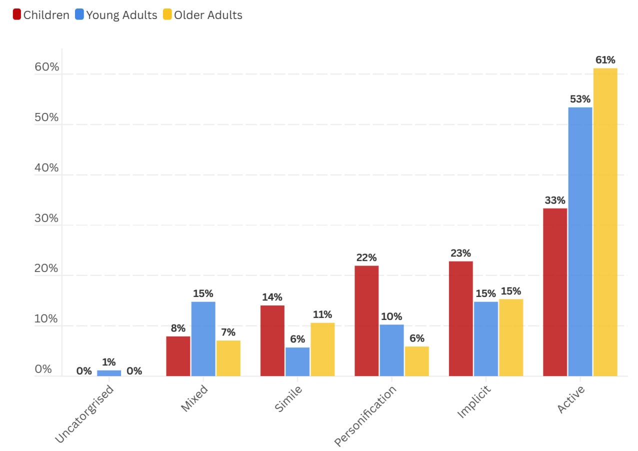


Figure 4: The percentage of different types of metaphors used by each age group.

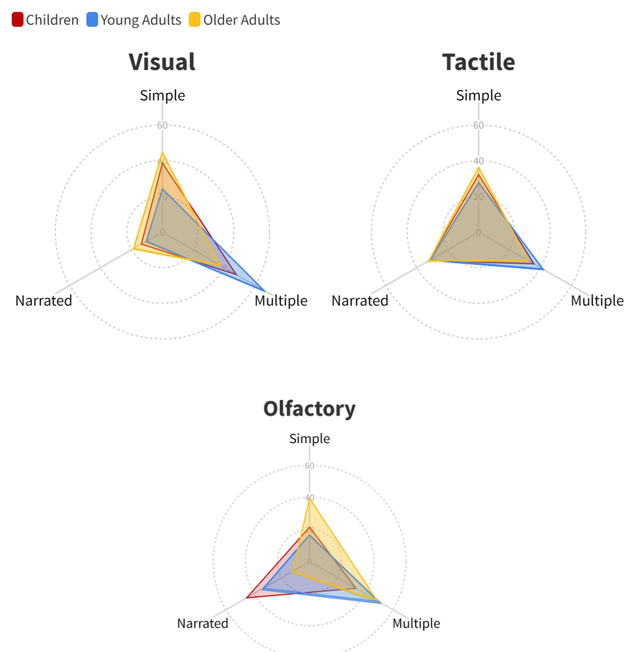
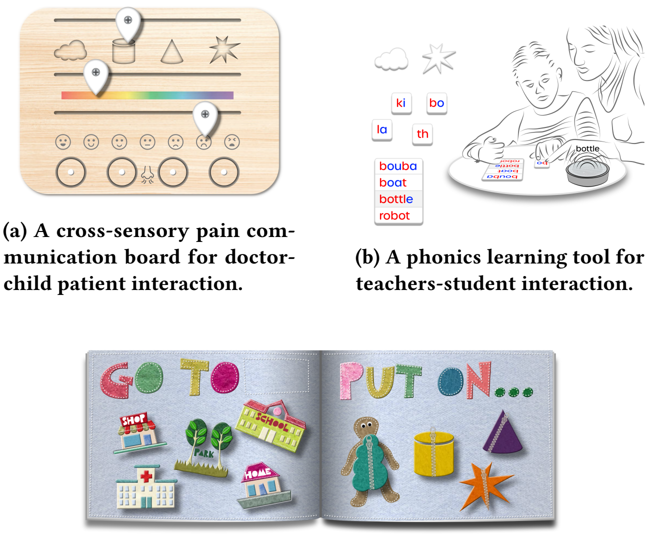


Figure 5: The degree of elaboration used by each age group, for each of the types of stimuli used

5 Examples: Leveraging Cross-sensory Metaphor to Design for Intergenerational Communication

Previous technological systems facilitating intergenerational communication have faced challenges related to how different generations perceive and interpret sensory cues. This prior research has established an understanding of the strategies used in cross-sensory communication. Now we leverage these findings to underlie design examples, which we introduce here. We suggest three designs for key intergenerational communication: doctor-child patient, teacher-student, and parent-child, that aim to solve some of the communication issues surrounding intergenerational communication.



(a) A cross-sensory pain communication board for doctor-child patient interaction.

(b) A phonics learning tool for teachers-student interaction.

(c) A storytelling busy book for child-parent emotion communication.

Figure 6: Three examples leveraging cross-sensory metaphors in the design of intergeneraitonal communication.

5.1 Doctor and Child Patient

It is important for doctors and their child-patients to effectively communicate, so the patient can accurately express what pain they are feeling and the issues with their health [30]. However, there are challenges involved as children struggle to communicate and may not understand questions doctors ask, like "is it a burning pain?" Despite these challenges, Tates et al. [78] found that current studies on doctor-patient communication focus more on the interactions between doctors and the child's parent, as opposed to the child. Bergeijk et al. [84] designed a tangible device which involved using tokens to represent different topics they wanted to address with a doctor. These tokens are then taken, and the doctor can bring up each one to support children addressing the topics they wish to discuss. However, this does not support children to actually communicate what they are feeling, instead focusing on tackling the issue of making the child patient feel like they are involved in the conversation.

Here we present an idea for a clinical communication aid (SeeFigure 6a), which focusses specifically on helping a child to communicate their experience, rather than simply participate in the conversation. This tool is a board which has sliders on so children can communicate the type of pain they are feeling without or in addition to using their words, thereby overcoming potential miscommunications between doctors and their patients. This clinical communication aid could employ cross-sensory interaction to facilitate intergenerational communication between a doctor, and a child patient. The board has sliders for different colours, round shapes to sharp shapes, different emotions and different smells. Findings from our study highlight the importance of smell to children. This novel design emphasises this discovery by including smells as options for cross-sensory expression. When interacting with the doctor, the child may move the sliders to respond to the doctor's questions regarding the pain experienced. The doctor could then use these likely cross-sensory associations to attain improved understanding of the child's experience and needs.

5.2 Teacher and Child

Teacher-student communication is fundamental to effective learning, fostering trust, and addressing individual student needs [4, 27]. Effective communication enables teachers to convey knowledge, provide feedback, and inspire students [75]. However, communicating effectively with young children presents unique challenges as they may have limited language skills and varying levels of social development, making it difficult for teachers to engage them fully. To overcome these barriers, educational technology has been a growing field.

Here we present an idea for an interactive educational tool, shown in Figure 6b, for teachers to improve their phonics teaching processes. Previous work has shown that children will readily form associations between phonemes and shapes and that this mechanism has potential for use in phonics education [22]. This tool provides a basis for phonics education through grapheme, shape and phoneme association. It has grapheme and shape pieces, and a board with radio frequency identification (RFID) enabled speaker function. Phonemes can be checked by moving grapheme pieces onto the sounding location on the board. Phonemes can be temporarily assigned to shape pieces by placing them together with a grapheme piece on the association location on the board. These newly assigned pieces can be sounded out by moving them to the sounding location on the board. Combinations of grapheme and assigned shape pieces allow the construction of entire words, helping with phonic learning. The addition of shape pieces to this tool reflects our previous findings that children tend to use personification more than adults. By considering the characteristics of shapes, and generating more shape-phoneme associations, children may use another avenue of retrieval when grasping for their grapheme representations. This can support the teacher in multiple ways, such as gaining insight into individual preferences of the phoneme shape associations of a child, and providing another modality of communication through the phonemes produced by the sounding element of the board. .

5.3 Parent and Child

Intergenerational communication plays a crucial role in fostering understanding and collaboration across age groups with good parent-child communication essential for optimal development. Parent-child communication fosters emotional bonding and aids in the development of social and cognitive skills [43, 63]. Although, parents often face difficulties in addressing and understanding children's emotions, especially in stressful or complex scenarios [80]. Theofanopoulou et al, explored the tools designed to support these issues and found that a lack of tools and resources to navigate emotional conversations and variations in family dynamics, cultural norms, and individual preferences complicate solutions. [80]. They suggested storytelling should be explored as a means of fostering child-parent communication, as both parents and children react positive to storytelling elements that scaffold learning around emotional experiences. When considering the use of technology to improve parent-child communication, storytelling has again been highlighted as good way to foster understanding and create developmental opportunities [80].

Engaging findings from this study, we present the design idea of a storybook based technology to facilitate intergenerational communication of emotions (Figure 6c). This interactive storybook uses cross-sensory associations to provide an intergenerational communication aid by building on a busy book design, in combination with storytelling features. The findings of this study demonstrated that all age groups used familiar experience to create connections. This finding is utilised in this design example through scenario presentation. The cross-sensory busy book has pages with scenarios inspired by daily life, such as visiting certain locations, or getting dressed. Tactile, manipulable features provide tangible sensory interaction opportunities and customisable options. For example, when getting dressed there are clothing options presented as various shapes and colours, with zips, poppers and Velcro. These can be selected and swapped to dress a character. For each page, a button is available, which generates an emotion when pressed. This emotion is sounded aloud by the book and creates an emotional setting for each page activity. The child physically manipulates the options on the page, leveraging our fingers around embodied forms of cross-sensory metaphors to create concordance between the emotion and the representation of the activity on the page. This prompted feedback provides a basis for conversation between parent and child. It also enables parents to attain insight into the child's perception and provides a scaffold for parental elaboration and teaching. The emotion generated when the button is pressed will be different each time, and the tactile manipulable options are varied. This ensures a wide range of possible routes through the book. By creating divergent narrative options, rather than the traditionally convergent style of a predetermined story, multiple possible journeys can be elaborated and explored together, thereby facilitating depth of skill in communication.

5.4 Further Examples

While we have presented three design examples based on our findings, their potential applications extend further. One promising use case involves fostering connections between children and their grandparents over long distances. Current research highlights the use of tangible interfaces, sensory experiences, and playful interactions to bridge generational gaps [7, 87]. Our storybook design could be adapted for distance communication, offering a tool to support long-distance intergenerational interaction. Another potential application relates to older adults and their sense of smell. Research indicates that older adults need to actively train their sense of smell to mitigate age-related sensory decline [8, 9]. Designing technologies that enable children and older adults to communicate about scents could simultaneously support older adults in maintaining their olfactory function, help children develop language around smell, and address challenges in intergenerational communication.

The above design examples presented here provide a basis for the application of the findings of this study. By incorporating cross-sensory strategies, these examples could overcome some of the shortcomings of previous technological systems designed to facilitate intergenerational communication. The key areas of intergenerational communication addressed here provide a selection of opportunity spaces. Further work should explore other key areas for the provision of technology that uses knowledge of cross-sensory strategies to foster intergenerational communication.

6 Discussion

Overall, our research provides insights into how individuals of different ages communicate cross-sensory experiences, contributing to a deeper understanding of the language and strategies used in such interactions. By exploring cross-sensory communication across distinct age groups, this study highlights both the shared patterns and the differences that emerge in the ways participants create and articulate their metaphors. This work not only expands the existing knowledge of cross-sensory experiences, but also underscores the communication nuances between age groups that could influence the design of interactive systems.

6.1 Association Strategies in Cross-sensory Metaphor Construction

The results indicate that *familiar experience* was the most predominantly used strategy across all age groups, highlighting its broad applicability in cross-sensory communication. This suggests that incorporating universally recognisable and relatable items or experiences into the design of tools aimed at supporting intergenerational communication could enhance their effectiveness. For children, *familiar experience* was the dominant strategy across all sensory modalities, demonstrating its central role in how younger participants interpret and express sensory information. In contrast, young adults frequently relied on *personal connections* when describing sounds, while older adults predominantly used *personal connections* for taste and sound, and *sensory features* for emotions. These findings suggest that for audio-based modalities, particularly for young and older adults, incorporating opportunities for personal connections and nostalgia could improve engagement and communication.

The role of audio in fostering personal connections is supported by prior research. Dib et al. [25] found that sound can facilitate richer and more varied social remembering compared to visual stimuli alone, particularly in familial and creative contexts. This highlights the complementary relationship between audio and personal connections in enhancing shared experiences and communication.

An additional finding was the limited use of *embodiment* across all age groups. However, whenever participants used *embodied communication*, we observed that the other team consistently guessed the stimuli being described correctly. This suggests that incorporating *embodied communication* into design for intergenerational communication could be an effective approach for conveying cross-sensory experiences. Curtis et al. [23] demonstrated the potential of embodied frameworks within assistive technology, showing how they can provide a multidimensional and richer account of sensory experiences.

In contrast, the *valence* strategy was rarely employed, diverging from findings in previous research where it was a more prominent strategy [46, 51]. This discrepancy may stem from differences in the study context, as participants in prior studies were not required to communicate their cross-sensory connections to others. Valence may be less effective for sharing cross-sensory experiences, as it is inherently general and highly subjective. For instance, one individual may associate the colour red with positive emotions as their favourite colour, while another may associate it with negativity, leading to opposing metaphors when relying on valence. This variability underscores the potential limitations of valence as a communicative strategy in contexts requiring shared understanding.

6.2 Degrees of Elaboration in Cross-sensory Metaphor Construction

Tactile stimuli were described with a consistent degree of elaboration across all age groups. This observation aligns with a substantial body of research on tangible interfaces as effective tools for intergenerational communication [12, 74, 87, 89, 90], supporting the idea that touch is a universally understood and accessible modality. Visual stimuli, on the other hand, were typically described using simple or multiple degrees of elaboration, with young adults more frequently employing multiple degrees. This suggests that young adults may prefer slightly more detailed descriptions when engaging with visual stimuli, potentially reflecting their developmental stage or familiarity with visual communication. Colours, widely used in design and marketing as communicative tools [5, 66], were often conveyed through simple or multiple metaphors. This is likely due to the universal recognition of colours and their capacity to convey meaning across diverse contexts, making them an intuitive medium for communication.

In contrast, olfactory stimuli exhibited the greatest variation in degrees of elaboration across age groups. Children tended to use narrated degrees of elaboration, young adults favoured multiple degrees, and older adults predominantly used simple or multiple degrees. These findings suggest that as individuals age, they may find it easier to describe olfactory experiences with simpler elaborations, whereas younger individuals may require more extensive descriptions to articulate their sensory impressions. This raises important considerations for designing tools that rely on olfactory communication, particularly for younger age groups, who may benefit from early exposure to discussing and practising olfactory descriptions. The challenges associated with olfactory communication are well-documented, particularly in Western languages, which lack specialised vocabulary for describing smells [3]. Alač [3] emphasises that effective olfactory communication can develop through practice, underscoring the importance of introducing children to discussions about olfactory stimuli at an early age. Encouraging such discussions may not only familiarise children with olfactory terminology but also enhance their ability to engage with olfactory-based interfaces in later stages of life.

These findings suggest that visual and auditory stimuli may serve as more reliable mediums for intergenerational communication, given the consistent levels of elaboration across age groups. However, the variability observed with olfactory stimuli highlights a need for further exploration into how olfactory communication can be supported across different age groups, particularly in cross-generational settings.

6.3 Type of Cross-sensory Metaphor Construction

Regarding the types of metaphors used by different age groups, older adults demonstrated the highest usage of direct metaphors, closely followed by young adults. This suggests that designs targeting these age groups could benefit from being explicit and straightforward. Campbell et al. [14] emphasise that communication with older adults should be clear and direct to minimise miscommunication, often influenced by differences in sensory abilities. Ensuring explicitness in designs for older adults can thus enhance usability and reduce potential barriers to effective interaction.

Children, on the other hand, exhibited a more varied approach, using a combination of direct, implied, and personification metaphors, with personification being particularly prominent compared to the other groups. This indicates that designs for children could integrate a mix of metaphor styles to align with their broader usage. The strong preference for personification among children also highlights the effectiveness of anthropomorphism, making objects or characters appear human-like [52], as a means to engage them more effectively. Anthropomorphism has been widely used in technology to capture children's attention and foster engagement. For example, Festerling et al. [35] found that anthropomorphism is often applied in digital voice assistants to engage children, with some evidence suggesting that it can enhance children's social cognition [6]. Incorporating anthropomorphic elements into designs for children may thus not only make the experience more relatable but could also serve as a tool for enhancing social interaction and learning around cross-sensory experiences. By aligning the type of cross-sensory metaphors and design approaches with the preferences of each age group, technology can be tailored to improve communication and engagement across diverse user demographics.

6.4 Reflections on the Chemical Senses in Cross-sensory Metaphor Construction

In HCI, chemical senses such as smell and taste often present challenges in terms of hardware development [11] and in understanding how individuals engage with these senses in interaction contexts [61]. These challenges suggest that our participants would resort to strategies like *grasping for another sense* when describing smells, or when using smell and taste as expression modalities due to the limited vocabulary available for olfactory and, to some extent, gustatory experiences. However, our findings did not align with this expectation. Instead, participants predominantly relied on *familiar experiences* and *personal connections* when describing smell and taste. This discrepancy may be attributed to the design of our study, which explicitly asked participants to discuss smell and taste without imposing restrictions on how they described these sensory modalities. This open-ended approach likely encouraged participants to draw on relatable experiences or personal memories, circumventing the need to rely on indirect strategies like *grasping for another sense*.

Interestingly, the influence of age was evident when analysing the degree of elaboration used to describe smells. Children frequently employed a narrated degree of elaboration, providing longer and more detailed descriptions compared to older participants, who tended to be more concise. This finding aligns with prior research suggesting that as individuals age, they may develop a more refined ability to describe scents succinctly, while younger individuals often rely on extended, detailed expressions to compensate for their limited sensory vocabulary [20]. This highlights the importance of developing sense-related vocabularies early on to support children's ability to articulate their sensory experiences more effectively.

6.5 Limitations and Future Work

This exploratory study focused on three broad age groups: children (8–11 years), young adults (18–24 years), and older adults (60–85 years). While this approach provided a foundational understanding of age-related differences in cross-sensory metaphor creation, future research could benefit from examining narrower age ranges to uncover additional nuances in how specific age groups construct and communicate cross-sensory metaphors. Furthermore, investigating how age groups communicate cross-sensory experiences with peers from different age groups may provide insights into the causes of miscommunication across generations.

A promising direction for future work could involve conducting the same game with mixed-age groups, such as having children communicate stimuli to older adults or vice versa. This approach would allow for a direct comparison of intra-age group versus inter-age group interactions, revealing how communication styles and metaphor use differ in these contexts.

Another limitation was the range of sensory items used in this study. While we focused on items associated with smell, sight, and touch, future work could incorporate stimuli related to sound and taste. Expanding the sensory modalities studied would provide a more comprehensive understanding of the language used to describe all senses, potentially uncovering unique strategies associated with underexplored modalities like auditory and gustatory stimuli.

The study's exploratory nature also introduced some methodological limitations. For example, we did not include a control group to isolate the effects of the intervention, nor did we control the time participants spent playing the game. These choices were intentional, as the primary aim was to gather preliminary insights rather than establish causal relationships. However, future research could address these limitations by incorporating a control group to better isolate the most effective cross-sensory metaphors and implementing structured time constraints to ensure consistency in gameplay duration. By addressing these methodological limitations, researchers could draw clearer and more generalisable conclusions about cross-sensory metaphor use and its implications for communication and design.

6.5.1 Cultural Limitations. One of the groups in our study consisted of participants whose first language was not English. These participants found it challenging to create descriptions in English and often reverted to their native language. This highlights an intriguing avenue for future research into the role of language proficiency in cross-sensory communication. Moreover, given that culture significantly influences metaphor construction [76, 81], future studies could explore how cultural differences shape the formation of cross-sensory metaphors and whether cultural context impacts their effectiveness.

7 Conclusion

This exploratory study investigated how different age groups create and communicate using cross-sensory metaphors, providing insights to support intergenerational communication. Our analysis identified *familiar experience* as the predominant strategy across all age groups, with children relying heavily on it, young adults frequently using *personal connection*, and older adults employing a broader range of strategies. While tactile and visual stimuli elicited consistent degrees of elaboration across ages, olfactory descriptions varied, with children using more detailed narratives and older adults being more concise. Metaphor types also differed, with children favouring implicit metaphors, similes, and personification, while young and older adults primarily used active metaphors. These findings suggest that sensory perception and communication strategies evolve with age. To address these differences, we propose examples and future work in technology designs that leverage cross-sensory metaphors to enhance communication across generations.

8 Selection and Participation of Children

Children in this study were part of an activity day, where multiple schools attended two of the author's University and participated in multiple different studies. When they first got to the university, they were given housekeeping information and the first task they took part in was about data, research and assent. They were told that anything they created on the day did not have to be handed in if they didn't want to. The children's parents all gave consent and children's names and ages were not collected. This study received full ethical approval.

Acknowledgments

This work is part of the ERC-selected UKRI funded project inclusiveXplay, Grant no.: EP/Y023676/1, and RAEng Grant no.: ING2022/16/100171. We would like to thank all the participants who took part in this study. We would like to thank Age UK and the FAB groups specifically for their support.

References

[1] Zsuzsanna Ittzés Abrams. 2020. *Miscommunication, Conflict, and Intercultural Communicative Competence.* Cambridge University Press.

[2] Akua Ahyia Adu-Oppong and Emmanuel Agyin-Birikorang. 2014. Communication in the workplace: Guidelines for improving effectiveness. *Global journal of commerce & management perspective* 3, 5 (2014), 208–13.

[3] Morana Alač. 2017. We like to talk about smell: A worldly take on language, sensory experience, and the Internet. *Semiotica* 2017, 215 (2017), 143–192. doi:10.1515/sem-2015-0093

[4] Glory Amadi and Kufre Paul Akpan. 2017. Influence of Student-Teacher Communication on Students' Academic Achievement for Effective Teaching and

Learning. *American Journal of Educational Research* 5, 10 (2017), 1102–1107. https://pubs.sciepub.com/education/5/10/12

[5] Mubeen M Aslam. 2006. Are you selling the right colour? A cross-cultural review of colour as a marketing cue. *Journal of marketing communications* 12, 1 (2006), 15–30.

[6] Gray Atherton and Liam Cross. 2018. Seeing More Than Human: Autism and Anthropomorphic Theory of Mind. *Frontiers in Psychology* 9 (2018). doi:10.3389/fpsyg.2018.00528

[7] Benett Axtell, Cheng Yin Zhu, and Carman Neustaedter. 2024. Bridges, Glitter, and *Spaceship Noises*: Young Children's Design Ideas for Communication Across Distance. In *Proceedings of the 23rd Annual ACM Interaction Design and Children Conference* (Delft, Netherlands) *(IDC '24)*. Association for Computing Machinery, New York, NY, USA, 379–395. doi:10.1145/3628516.3655800

[8] Ceylan Beşevli, Giada Brianza, Christopher Dawes, Nonna Shabanova, Sanjoli Mathur, Matt Lechner, Emanuela Maggioni, Duncan Boak, Carl Philpott, Ava Fatah Gen. Schieck, and Marianna Obrist. 2024. Smell Above All: Envisioning Smell-Centred Future Worlds. In *Proceedings of the 2024 ACM Designing Interactive Systems Conference* (Copenhagen, Denmark) *(DIS '24)*. Association for Computing Machinery, New York, NY, USA, 2530–2544. doi:10.1145/3643834.3660699

[9] Ceylan Beşevli, Christopher Dawes, Giada Brianza, Ava Fatah Gen. Schieck, Duncan Boak, Carl Philpott, Emanuela Maggioni, and Marianna Obrist. 2023. Nose Gym: An Interactive Smell Training Solution. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI EA '23)*. Association for Computing Machinery, New York, NY, USA, Article 464, 4 pages. doi:10.1145/3544549.3583906

[10] Margaret M Bradley and Peter J Lang. 2007. *The International Affective Digitized Sounds (; IADS-2): Affective ratings of sounds and instruction manual.* Technical Report. Technical report B-3. University of Florida, Gainesville, Fl.

[11] Jas Brooks, Alireza Bahremand, Pedro Lopes, Christy Spackman, Judith Amores Fernandez, Hsin-Ni Ho, Masahiko Inami, and Simon Niedenthal. 2023. Sharing and Experiencing Hardware and Methods to Advance Smell, Taste, and Temperature Interfaces. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI EA '23)*. Association for Computing Machinery, New York, NY, USA, Article 362, 6 pages. doi:10.1145/3544549.3573828

[12] Xueyan Cai, Kecheng Jin, Shang Shi, Shichao Huang, Ouying Huang, Xiaodong Wang, Jiahao Cheng, Weijia Lin, Jiayu Yao, Yuqi Hu, Chao Zhang, and Cheng Yao. 2024. "See, Hear, Touch, Smell, and,...Eat!": Helping Children Self-Improve Their Food Literacy and Eating Behavior through a Tangible Multi-Sensory Puzzle Game. In *Proceedings of the 23rd Annual ACM Interaction Design and Children Conference* (Delft, Netherlands) *(IDC '24)*. Association for Computing Machinery, New York, NY, USA, 270–281. doi:10.1145/3628516.3655801

[13] Cambridge Dictionary. n.d.. Metaphor. https://dictionary.cambridge.org/dictionary/english/metaphor. Accessed: 2024-09-03.

[14] Janis M Campbell and Jeanette Lancaster. 1988. Communicating effectively with older adults. *Family & Community Health* 11, 3 (1988), 74–85.

[15] N. Carriedo, A. Corral, P. R. Montoro, L. Herrero, P. Ballestrino, and I. Sebastián. 2016. The Development of Metaphor Comprehension and Its Relationship with Relational Verbal Reasoning and Executive Function. *PLoS One* 11, 3 (2016), e0150289. doi:10.1371/journal.pone.0150289

[16] Yi-Chuan Chen, Pi-Chun Huang, Andy Woods, and Charles Spence. 2016. When "Bouba" equals "Kiki": Cultural commonalities and cultural differences in sound-shape correspondences. *Scientific reports* 6, 1 (2016), 26681.

[17] Haeun Chung, Kyungrang Baik, Jihye Cheon, Young Tae Kim, and Dongsun Yim. 2024. Children's communication repair strategies: Online versus face-to-face interaction. *Journal of Communication Disorders* 108 (2024), 106406. doi:10.1016/j.jcomdis.2024.106406

[18] James M Clark and Allan Paivio. 1991. Dual coding theory and education. *Educational psychology review* 3 (1991), 149–210.

[19] M. S. Cometa and M. E. Eson. 1978. Logical operations and metaphor interpretation: A Piagetian model. *Child Development* 49 (1978), 649–659.

[20] Patricia Cornelio, Carlos Velasco, and Marianna Obrist. 2021. Multisensory integration as per technological advances: A review. *Frontiers in neuroscience* 15 (2021), 652611.

[21] National Research Council, Board on Behavioral, Sensory Sciences, Committee on Developments in the Science of Learning with additional material from the Committee on Learning Research, and Educational Practice. 2000. *How people learn: Brain, mind, experience, and school: Expanded edition.* Vol. 1. National Academies Press.

[22] Clare Cullen and Oussama Metatla. 2020. Tangible Multisensory Aids for Collaborative Phonics Learning. In *Companion Publication of the 2020 Conference on Computer Supported Cooperative Work and Social Computing* (Virtual Event, USA) *(CSCW '20 Companion)*. Association for Computing Machinery, New York, NY, USA, 245–250. doi:10.1145/3406865.3418342

[23] Humphrey Curtis and Timothy Neate. 2024. Beyond Repairing with Electronic Speech: Towards Embodied Communication and Assistive Technology. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '24)*. Association for Computing Machinery, New York, NY, USA, Article 59, 12 pages. doi:10.1145/3613904.3642274

[24] Aleksandra Ćwiek, Susanne Fuchs, Christoph Draxler, Eva Liina Asu, Dan Dediu, Katri Hiovain, Shigeto Kawahara, Sofia Koutalidis, Manfred Krifka, Pärtel Lippus, et al. 2022. The bouba/kiki effect is robust across cultures and writing systems. *Philosophical Transactions of the Royal Society B* 377, 1841 (2022), 20200390.

[25] Lina Dib, Daniela Petrelli, and Steve Whittaker. 2010. Sonic souvenirs: exploring the paradoxes of recorded sound for family remembering. In *Proceedings of the 2010 ACM Conference on Computer Supported Cooperative Work* (Savannah, Georgia, USA) *(CSCW '10)*. Association for Computing Machinery, New York, NY, USA, 391–400. doi:10.1145/1718918.1718985

[26] A. L. Dieuleveult, P. C. Siemonsma, J. B. F. van Erp, and A.-M. Brouwer. 2017. Effects of Aging in Multisensory Integration: A Systematic Review. *Frontiers in Aging Neuroscience* 9 (2017), 80. doi:10.3389/fnagi.2017.00080

[27] Nicole D. Dobransky and Ann Bainbridge Frymier. 2004. Developing teacher-student relationships through out of class communication. *Communication Quarterly* 52, 3 (2004), 211–223. doi:10.1080/01463370409370193 arXiv:https://doi.org/10.1080/01463370409370193

[28] Julie Dockrell. 1999. *Children's language and communication difficulties.* Bloomsbury Publishing, The tower Building, 11 York Road, London SE1 7NX.

[29] Norman Elliott. 1984. Communicative development from birth. *Western Journal of Speech Communication* 48, 2 (1984), 184–196. doi:10.1080/10570318409374153

[30] Ronald M. Epstein. 2000. The science of patient-centered care. *Journal of Family Practice* 49, 9 (Sept. 2000), 805–807.

[31] Feng Feng, Dan Bennett, Zhi-jun Fan, and Oussama Metatla. 2022. It's Touching: Understanding Touch-Affect Association in Shape-Change with Kinematic Features. In *CHI Conference on Human Factors in Computing Systems*. ACM, New Orleans LA USA, 1–18. doi:10.1145/3491102.3502003

[32] Feng Feng, Dan Bennett, and Elisa D. Mekler. 2024. Smiles Summon the Warmth of Spring: A Design Framework for Thermal-Affective Interaction based in Chinese Cí Poetry. In *Designing Interactive Systems Conference*. ACM, IT University of Copenhagen Denmark, 2802–2819. doi:10.1145/3643834.3661620

[33] Feng Feng and Elisa D. Mekler. 2025. Thermal Cards: From Classical Chinese Poetry to Designerly Lenses on Thermal-Affective Technology. In *Proceedings of the ACM International Conference on Tangible, Embedded and Embodied Interaction (TEI)*. ACM, Bourdeaux, France. doi:10.1145/3689050.3704419

[34] Silvia Ferrando, Erica Volta, and Gualtiero Volpe. 2022. Multisensory Technologies to Support Teaching: an Ongoing Project. In *Proceedings of the 21st Annual ACM Interaction Design and Children Conference* (Braga, Portugal) *(IDC '22)*. Association for Computing Machinery, New York, NY, USA, 557–563. doi:10.1145/3501712.3535284

[35] Janik Festerling and Iram Siraj. 2022. Anthropomorphizing technology: a conceptual review of anthropomorphism research and how it relates to children's engagements with digital voice assistants. *Integrative Psychological and Behavioral Science* 56, 3 (2022), 709–738.

[36] Mathilde Fort, Alexa Weiß, Alexander Martin, and Sharon Peperkamp. 2013. Looking for the bouba-kiki effect in prelexical infants. In *Auditory-Visual Speech Processing (AVSP) 2013*. Auditory-Visual Speech Processing (AVSP) 2013, Laboratoire de Sciences Cognitives et Psycholinguistique, ENS-CNRS-EHESS, Paris, France.

[37] Elia Gatti, Elena Calzolari, Emanuela Maggioni, and Marianna Obrist. 2018. Emotional ratings and skin conductance response to visual, auditory and haptic stimuli. *Scientific data* 5, 1 (2018), 1–12.

[38] Sam Glucksberg. 1989. Metaphors in Conversation: How Are They Understood? Why Are They Used? *Metaphor and Symbolic Activity* 4, 3 (1989), 125–143. doi:10.1207/s15327868ms0403_2

[39] Jake Harwood. 2006. Communication Media Use in the Grandparent-Grandchild Relationship. *Journal of Communication* 50, 4 (01 2006), 56–78. doi:10.1111/j.1460-2466.2000.tb02863.x arXiv:https://academic.oup.com/joc/article-pdf/50/4/56/22335116/jjnlcom0056.pdf

[40] Erika Hoff. 2001. *Language development.* Wadsworth/Thomson Learning.

[41] Erika Hoff. 2006. How social contexts support and shape language development. *Developmental review* 26, 1 (2006), 55–88.

[42] Dawn Janssen and Stephen Carradini. 2021. Generation Z workplace communication habits and expectations. *IEEE Transactions on Professional Communication* 64, 2 (2021), 137–153.

[43] Bonnie Klimes-Dougan and Janice Zeman. 2007. Introduction to the Special Issue of Social Development: Emotion Socialization in Childhood and Adolescence. *Social Development* 16, 2 (2007), 203–209. doi:10.1111/j.1467-9507.2007.00380.x arXiv:https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1467-9507.2007.00380.x

[44] George Lakoff and Mark Johnson. 2008. *Metaphors we live by.* University of Chicago press.

[45] Peter Lang and Margaret M Bradley. 2007. The International Affective Picture System (IAPS) in the study of emotion and attention. *Handbook of emotion elicitation and assessment* 29 (2007), 70–73.

[46] Anan Lin, Meike Scheller, Feng Feng, Michael J Proulx, and Oussama Metatla. 2021. Feeling Colours: Crossmodal Correspondences Between Tangible 3D Objects, Colours and Emotions. In *Proceedings of the 2021 CHI Conference on Human Factors*

in Computing Systems (Yokohama, Japan) *(CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 187, 12 pages. doi:10.1145/3411764.3445373

[47] Emanuela Maggioni, Robert Cobden, Dmitrijs Dmitrenko, and Marianna Obrist. 2018. Smell-O-Message: Integration of Olfactory Notifications into a Messaging Application to Improve Users' Performance. In *Proceedings of the 20th ACM International Conference on Multimodal Interaction (ICMI '18)*. Association for Computing Machinery, New York, NY, USA, 45–54. doi:10.1145/3242969.3242975

[48] Daphne Maurer, Thanujeni Pathman, and Catherine J Mondloch. 2006. The shape of boubas: Sound–shape correspondences in toddlers and adults. *Developmental science* 9, 3 (2006), 316–322.

[49] Robert McCann and Howard Giles. 2002. Ageism in the workplace: A communication perspective. (2002).

[50] B. Mejía-Constaín, O. Monchi, N. Walter, M. Arsenault, N. Senhadji, and Y. Joanette. 2010. When metaphors go literally beyond their territories: the impact of age on figurative language. *Italian Journal of Linguistics* 22 (2010), 41–60.

[51] Oussama Metatla, Emanuela Maggioni, Clare Cullen, and Marianna Obrist. 2019. "Like Popcorn": Crossmodal Correspondences Between Scents, 3D Shapes and Emotions in Children. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI '19)*. Association for Computing Machinery, New York, NY, USA, 1–13. doi:10.1145/3290605.3300689

[52] Robert W Mitchell, Nicholas S Thompson, and H Lyn Miles. 1997. *Anthropomorphism, anecdotes, and animals*. Suny Press.

[53] Sherwyn P. Morreale, Michael M. Osborn, and Judy C. Pearson. 2000. Why Communication is Important: A Rationale for the Centrality of the Study of Communication. *Journal of the Association for Communication Administration* 29, 1 (2000), 1–25. Published in 2000.

[54] Tova Most. 2002. The Use of Repair Strategies by Children With and Without Hearing Impairment. *Language, Speech, and Hearing Services in Schools* 33, 2 (April 2002), 112–123. doi:10.1044/0161-1461(2002/009)

[55] Marianna Obrist, Sue Ann Seah, and Sriram Subramanian. 2013. Talking about tactile experiences. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 1659–1668. http://dl.acm.org/citation.cfm?id=2466220

[56] Marianna Obrist, Sriram Subramanian, Elia Gatti, Benjamin Long, and Thomas Carter. 2015. Emotions mediated through mid-air haptics. In *Proceedings of the 33rd annual ACM conference on human factors in computing systems*. 2053–2062.

[57] Eunjung Oh and Thomas C. Reeves. 2014. *Generational Differences and the Integration of Technology in Learning, Instruction, and Performance*. Springer New York, New York, NY, 819–828. doi:10.1007/978-1-4614-3185-5_66

[58] Logan Reis, Kathryn Mercer, and Jennifer Boger. 2021. Technologies for fostering intergenerational connectivity and relationships: Scoping review and emergent concepts. *Technology in Society* 64 (2021), 101494. doi:10.1016/j.techsoc.2020.101494

[59] Leslie Rescorla and Jennifer Mirak. 1997. Normal language acquisition. *Seminars in Pediatric Neurology* 4, 2 (1997), 70–76. doi:10.1016/S1071-9091(97)80022-8 Language Disorders in Children.

[60] Tegan Joy Roberts-Morgan, Brooke Morris, Elaine Czech, Suhan Neema, Abigale Stangl, Kyle Michael Keane, Matthew Horton, Janet Read, and Oussama Metatla. 2024. Sense-O-Nary: Exploring Children's Crossmodal Metaphors Through Playful Crossmodal Interactions. In *Proceedings of the 23rd Annual ACM Interaction Design and Children Conference* (Delft, Netherlands) *(IDC '24)*. Association for Computing Machinery, New York, NY, USA, 259–269. doi:10.1145/3628516.3655785

[61] Walter A Rosenblith. 2012. *Sensory communication*. MIT press.

[62] Ted Ruffman, Julie D Henry, Vicki Livingstone, and Louise H Phillips. 2008. A meta-analytic review of emotion recognition and aging: Implications for neuropsychological models of aging. *Neuroscience & Biobehavioral Reviews* 32, 4 (2008), 863–881.

[63] Patricia Luciana Runcan, Corneliu Constantineanu, Brigitta Ielics, and Dorin Popa. 2012. The Role of Communication in the Parent-Child Interaction. *Procedia - Social and Behavioral Sciences* 46 (2012), 904–908. doi:10.1016/j.sbspro.2012.05.221 4th WORLD CONFERENCE ON EDUCATIONAL SCIENCES (WCES-2012) 02-05 February 2012 Barcelona, Spain.

[64] Ladan Shams and Aaron R Seitz. 2008. Benefits of multisensory learning. *Trends in cognitive sciences* 12, 11 (2008), 411–417.

[65] Chenxinran Shen, Joanna Mcgrenere, and Dongwook Yoon. 2024. LegacySphere: Facilitating Intergenerational Communication Through Perspective-Taking and Storytelling in Embodied VR. In *Proceedings of the CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '24)*. Association for Computing Machinery, New York, NY, USA, Article 119, 16 pages. doi:10.1145/3613904.3641923

[66] Satyendra Singh. 2006. Impact of color on marketing. *Management decision* 44, 6 (2006), 783–789.

[67] L. J. Speed, I. Croijmans, S. Dolscheid, and A. Majid. 2021. Crossmodal Associations with Olfactory, Auditory, and Tactile Stimuli in Children and Adults. *Iperception* 12, 6 (2021), 20416695211048513. doi:10.1177/20416695211048513

[68] Charles Spence. 2002. Multisensory attention and tactile information-processing. *Behavioural brain research* 135, 1-2 (2002), 57–64.

[69] Charles Spence. 2011. Crossmodal correspondences: A tutorial review. *Attention, Perception, & Psychophysics* 73 (2011), 971–995.

[70] Charles Spence and Ophelia Deroy. 2013. Crossmodal mental imagery. *Multisensory imagery* (2013), 157–183.

[71] Charles Spence and Ophelia Deroy. 2013. How automatic are crossmodal correspondences? *Consciousness and Cognition* 22, 1 (March 2013), 245–260. doi:10.1016/j.concog.2012.12.006

[72] Manfred Spitzer. 2009. The mind in context: Using fMRI to track metaphor processing in 20-year-olds and 60-year-olds. *Brain and Language* 109, 1 (2009), 1–12.

[73] Nicki Stanton. 1986. *Breakdowns in communication*. Macmillan Education UK, London, 17–28. doi:10.1007/978-1-349-10555-7_1

[74] Evropi Stefanidi, Julia Dominiak, Marit Bentvelzen, Paweł W. Woźniak, Johannes Schöning, Yvonne Rogers, and Jasmin Niess. 2023. MagiBricks: Fostering Intergenerational Connectedness in Distributed Play with Smart Toy Bricks. In *Proceedings of the 22nd Annual ACM Interaction Design and Children Conference* (Chicago, IL, USA) *(IDC '23)*. Association for Computing Machinery, New York, NY, USA, 239–252. doi:10.1145/3585088.3589390

[75] James H Stronge. 2018. *Qualities of effective teachers*. Ascd.

[76] Diana Stukan. 2018. Sociopragmatic failure: struggling with cross-cultural differences in communication. *Open Journal for Anthropological Studies* 2, 1 (2018).

[77] Vithya Subramaniam and Norizan Abdul Razak. 2014. Examining Language Usage and Patterns in Online Conversation: Communication Gap among Generation Y and Baby Boomers. *Procedia - Social and Behavioral Sciences* 118 (2014), 468–474. doi:10.1016/j.sbspro.2014.02.064 International Conference on Knowledge-Innovation-Excellence: Synergy in Language Research and Practice (2013), Organized by School of Language Studies and Linguistics, Faculty of Social Sciences and Humanities, Universiti Kebangsaan Malaysia (National University of Malaysia).

[78] Kiek Tates and Ludwien Meeuwesen. 2001. Doctor–parent–child communication. A (re)view of the literature. *Social Science & Medicine* 52, 6 (2001), 839–851. doi:10.1016/S0277-9536(00)00193-3

[79] Tazanfal Tehseem and Ahsan Bilal Khan. 2015. Exploring the use of metaphors in children literature: A discursive perspective. *European Journal of English Language, Linguistic and Literature* 2, 2 (2015), 7–17.

[80] Nikki Theofanopoulou, Alissa N. Antle, and Petr Slovak. 2024. "They Don't Come With a Handbook": Exploring Design Opportunities for Supporting Parent-Child Interaction around Emotions in the Family Context. *Proc. ACM Hum.-Comput. Interact.* 8, CSCW1, Article 132 (April 2024), 33 pages. doi:10.1145/3637409

[81] Jenny A. Thomas. 1983. Cross-Cultural Pragmatic Failure. *Applied Linguistics* 4 (1983), 91–112. https://api.semanticscholar.org/CorpusID:35667508

[82] Emilio Trifilio, Jeffrey B. Williamson, and Kenneth M. Heilman. 2019. Changes in Emotions and Mood with Aging. In *Cognitive Changes and the Aging Brain*, Kenneth M. Heilman and Stephen E. Nadeau (Eds.). Cambridge University Press, 127–139.

[83] D. Usnadze. 1924. Ein experimenteller Beitrag zum Problem der psychologischen Grundlagen der Namengebung. *Psychologische Forschung* 5 (1924), 24–43. doi:10.1007/BF00402395

[84] Marleen Van Bergeijk, Bart Hengeveld, and Selma Otto. 2017. DOK: Enhancing Child Patient Empowerment. In *Proceedings of the Eleventh International Conference on Tangible, Embedded, and Embodied Interaction* (Yokohama, Japan) *(TEI '17)*. Association for Computing Machinery, New York, NY, USA, 589–595. doi:10.1145/3024969.3025066

[85] Amy Volans and Emma Brown. 2021. Children expressing themselves. *Oxford Textbook of Palliative Care for Children* (2021), 95.

[86] R. Wales and G. Coffey. 1986. On children's comprehension of metaphor. In *Research Issues in Child Development*. Routledge, London and New York, 81–94.

[87] Torben Wallbaum, Andrii Matviienko, Swamy Ananthanarayan, Thomas Olsson, Wilko Heuten, and Susanne C.J. Boll. 2018. Supporting Communication between Grandparents and Grandchildren through Tangible Storytelling Systems. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (Montreal QC, Canada) *(CHI '18)*. Association for Computing Machinery, New York, NY, USA, 1–12. doi:10.1145/3173574.3174124

[88] Angie Williams and Jon F. Nussbaum. 2001. *Intergenerational Communication Across the Life Span*. Lawrence Erlbaum Associates Publishers, Mahwah, NJ.

[89] Bernhard Wohlmacher, Holger Klapperich, Fabian Mertl, and Alina Huldtgren. 2023. Overcoming technology and communication barriers in intergenerational communication with a tangible interface. In *Proceedings of Mensch Und Computer 2023* (Rapperswil, Switzerland) *(MuC '23)*. Association for Computing Machinery, New York, NY, USA, 508–512. doi:10.1145/3603555.3608554

[90] Bernhard Wohlmacher, Holger Klapperich, Fabian Mertl, and Alina Huldtgren. 2023. Overcoming technology and communication barriers in intergenerational communication with a tangible interface. In *Proceedings of Mensch Und Computer 2023* (Rapperswil, Switzerland) *(MuC '23)*. Association for Computing Machinery, New York, NY, USA, 508–512. doi:10.1145/3603555.3608554

[91] Wilhelm Wundt. 1913. *Grundriss der psychologie*. Kröner.

A Appendix

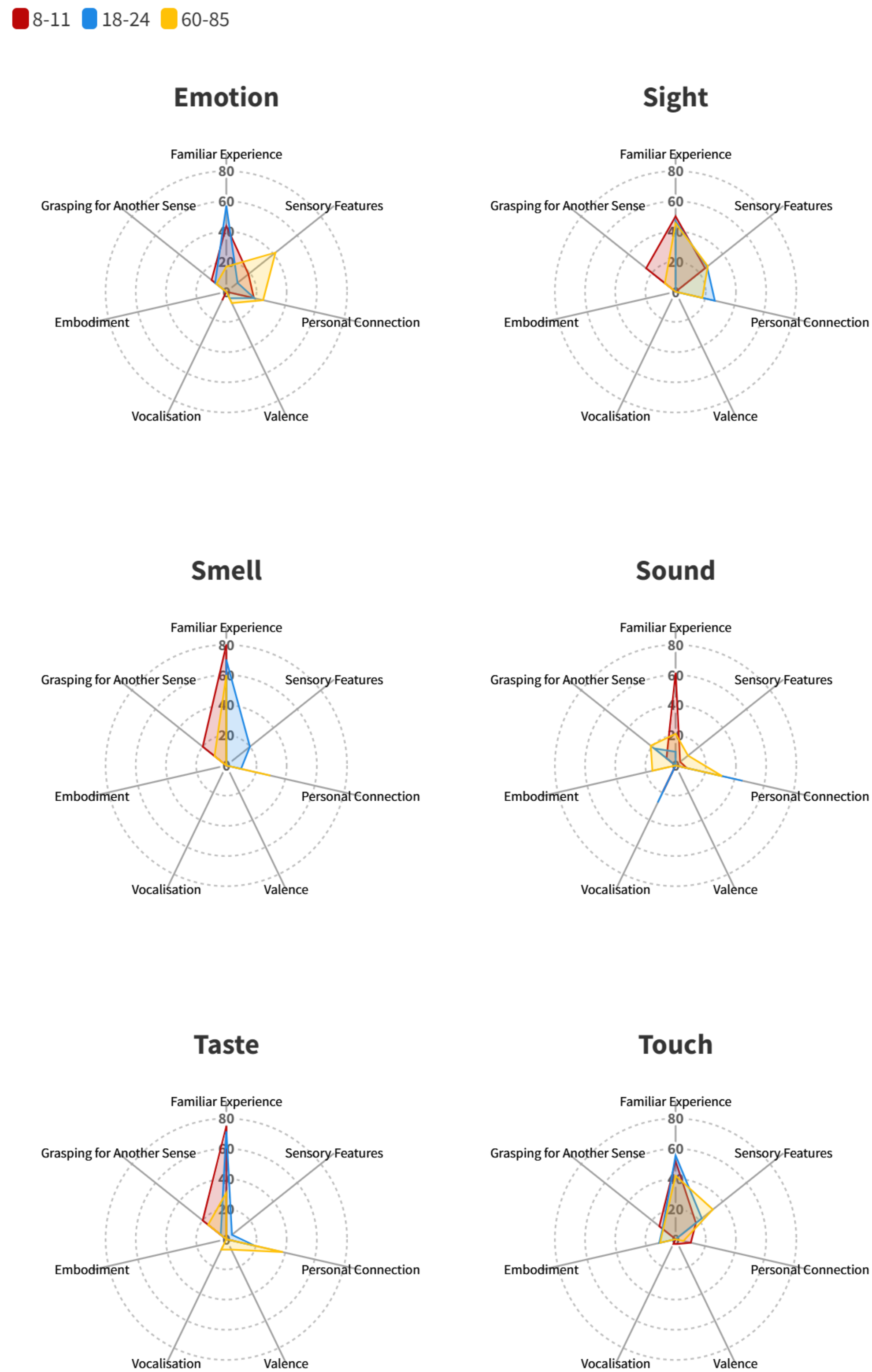


Figure 7: Radar graphs showing the association strategies used by each age group, for each expression modality or emotion the participants were asked to use for their descriptions, shown as a percentage.