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Sense-O-Plex: How Compositions of Cross-sensory Artefacts Shape Children's Collective Emotional Sense-Making

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Children increasingly encounter sensory-rich technologies in classrooms, museums, and play, yet little is known about how they collectively negotiate meanings across vision, touch, and smell while shared references and vocabularies are emerging. We introduce Sense-O-Plex, in which 52 children aged 8–11 worked in small groups to compose shared cross-sensory artefacts from visual, tactile, and olfactory items on an affect circumplex. Qualitative analysis of talk, gesture, action, and decisions shows that colours supported rapid consensus through familiar cultural associations; shapes prompted embodied exploration and negotiation; and scents exposed limits of shared reference, producing personal stories, disagreement, or conversational stalling. We contribute an account of how artefact composition, shareability, and manipulability shape participation, explanation, disagreement, and closure, with implications for collaborative sense-making technologies for children.

Cross-sensory Interaction; Affective Computing; Children; Collective Sense-making.

1. INTRODUCTION

Cross-sensory technologies increasingly support interaction through vision, sound, touch, and smell (Cornelio et al. 2021; Miura et al. 2023). For children, they offer embodied alternatives to screen-based interaction for learning, emotional expression, and social engagement (Volpe and Gori 2019; Cosentino et al. 2023). Prior work has largely focused on individual perception or mappings between sensory inputs and emotional categories (Roberts-Morgan et al. 2024; Metatla et al. 2019). We know less about how children compose sensory artefacts into shared cross-sensory arrangements and construct shared interpretations despite individual differences.

Children describe sensory experiences through interaction with peers, cultural references, and material artefacts (Spence 2022; Crichton-Fock et al. 2023). Collective and participatory sense-making perspectives understand meaning as constructed through coordinated talk, action, and attention (Weick and Weick 1995; Schiavio and De Jaegher 2017). Multimodal interaction makes this process apparent: children may compare, gesture, repeat, disagree, tell stories, or fall silent when a stimulus is unfamiliar or difficult to articulate (Renner 2011; Price et al. 2021; Weisberg and Newcombe 2017). In a composition task, such moments reveal both the resources and limits through which groups establish shared meaning.

Emotions provide a useful domain because children experience, communicate, and negotiate them with others (Kvist and Cekaite 2021; Denham 2007). Sensory artefacts can help children communicate feelings when verbal vocabularies are limited

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(Roberts-Morgan et al. 2024; Metatla et al. 2019), while a visual emotion representation can provide a shared reference for comparison and discussion (Hilppö et al. 2017; Clark 2011). Yet little is known about how the characteristics of different sensory modalities shape collective emotional reasoning. This matters for HCI because selecting and composing modalities shapes how readily an interpretation can be demonstrated, checked by peers, revised, or left unresolved; the composition itself therefore helps structure participation in the activity.

We address two research questions: RQ1: How do children build consensus when composing cross-sensory artefacts to express emotions? RQ2: What strategies and group dynamics emerge across sensory modalities? Sense-O-Plex asks groups to compose colours, scents, and 3D shapes by associating them with emotions on the Circumplex Model of Affect (Russell 1980). We use differences in recognisability, alongside ambiguous scents and neutral shapes, as comparative cases. Our central contribution is an interactional design account of how artefact familiarity, describability, and manipulability shape routes to alignment, negotiation, or agreement within a collective cross-sensory composition.

2. BACKGROUND

2.1. Collective and Cross-sensory Sense-making

Collective sense-making describes how people construct coherence through coordinated engagement with one another and with material artefacts (Weick and Weick 1995; Maitlis and Sonenshein 2010; Di Paolo and Thompson 2024; Price et al. 2021). In child-centred HCI, tangible representations can externalise ideas and establish shared referents through talk and manipulation (Veldhuis et al. 2020). Cross-sensory correspondences offer such resources, including Bouba–Kiki associations used in sensory interfaces (Ramachandran and Hubbard 2001; Metatla et al. 2019). Yet modalities differ in how readily interpretations become public: colours draw on reinforced associations (Valdez and Mehrabian 1994), shapes invite manipulation, and scents can evoke personal responses that are harder to describe (Olofsson and Pierzchajlo 2021; Zhang et al. 2016). We examine how these differences affect how a shared cross-sensory composition is assembled and the dynamics of collective sense-making of emotions.

2.2. Emotion as a Shared Reference

Because children may experience emotions more readily than they can articulate them, material expression can support communication (Knothe and Walle 2023; Boone and Cunningham 1998). The Circumplex Model of Affect positions emotions by valence and arousal (Russell 1980; Posner et al. 2005). Sense-O-Plex uses the circumplex as a shared surface on which groups can compose cross-sensory artefacts by placing, comparing, repositioning, and negotiating sensory meanings.

3. STUDY

3.1. Participants, Materials, and Procedure

Fifty-two children aged 8–11 participated in 18 teams of two to four during research engagement events organised with local schools. Children were recruited from three local schools and were randomly allocated to groups. Children were therefore familiar with each other but not necessarily friends. Parents provided consent through the schools, which retained the consent forms and did not share children's names with the research team. Children provided assent and were told that they could stop participating or withdraw their data. The study received full institutional ethical approval from [anonymised for review]. We selected four items from each of three modalities (Figure 1): lemon, mint, vanilla, and rose scents presented in cotton-filled jars (from commercial essential oils that were risk-assessed); red, green, yellow, and blue acrylic squares; and four 3D-printed shapes (Kiki, Bouba, cylinder, and pyramid). The set included stimuli with comparatively strong, neutral, or less explored associations in prior work (Ramachandran and Hubbard 2001).

Sense-O-Plex used the Circumplex Model of Affect, organising emotions by valence and arousal (Figure 2). Groups explored one item at a time, discussed the emotion it suggested, and placed it on the circumplex, progressively composing shared cross-sensory artefacts. They were told that there were no correct answers, that items need not be evenly distributed, and that disagreement was acceptable if participants tried to understand one another. Researchers remained present but did not guide decisions. Sessions lasted approximately ten minutes.

3.2. Data and Analysis

We recorded item placements and video/audio of group interaction. Figure 3 shows each team's cross-sensory composition. Content analysis of transcripts identified 361 descriptions across 18



(a) *Scents* ***(b)*** *Colours* ***(c)*** *Shapes*

Figure 1: *The visual, tactile, and olfactory items used to compose cross-sensory artefacts through Sense-O-Plex artefacts.*

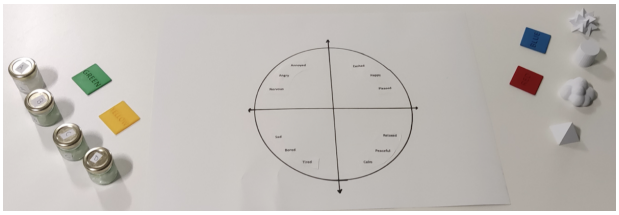


Figure 2: *Sense-O-Plex affect circumplex: excited, happy, and pleased (HVHA); relaxed, peaceful, and calm (HVLA); tired, bored, and sad (LVLA); nervous, angry, and annoyed (LVHA).*

teams (Elo and Kyngäs 2008). For association strategies, the unit of analysis was a discrete descriptive contribution: an utterance, vocalisation, or embodied expression through which a child linked one sensory item to an emotion, sensory feature, familiar experience, personal connection, or another item. Multiple distinct descriptions of the same item were counted separately, including when a child returned to the same item with a different rationale; contributions included statements such as "yellow is happy" and "This [Kiki] is very spiky, it feels like anger". Descriptions were coded using seven strategies drawn from prior work (Metatla et al. 2019; Roberts-Morgan et al. 2024; Lin et al. 2021; Roberts-Morgan et al. 2026): familiar experience, sensory features, internal coherence with another item, personal connection, valence, vocalisation, and embodied action. Two researchers reviewed and discussed a subset of data points to refine grouping decisions. Agreement was reached through iterative discussion within the research team across the whole data set.

For group dynamics, the unit of analysis was the item-level decision episode, from the first proposal about an item to its placement or the group's move to the next item. We examined how proposals were made available through talk or action, taken up or resisted by peers, and transformed into a collective placement within the emerging cross-sensory composition; participatory sense-making therefore operated as a sensitising perspective rather than as a separate deductive code. Six dynamics captured whether a proposal was immediately accepted, discussed before agreement, averaged with alternatives, accepted through compromise, resolved after collective uncertainty, or settled without clear agreement. These codes distinguish three broader interactional outcomes: immediate or reasoned alignment; negotiated resolution through averaging or compromise; and procedural closure following uncertainty or without explicit evidence of alignment. We then compared association strategies and dynamics across all sensory modalities. Coding was validated in a similar way to the association strategies.

4. FINDINGS

4.1. Emotional Associations

Colours produced the clearest shared associations. Most teams placed red in low-valence/high-arousal regions as angry, while blue clustered around low-valence/low-arousal sadness. Yellow tended towards high-valence/high-arousal happiness and green towards high-valence/low-arousal calmness, broadly aligning with established colour–emotion associations (Valdez and Mehrabian 1994; Read et al. 2025). **Shape** associations depended on distinctive material features. Kiki was consistently high-arousal and commonly negative, linked to spikiness, hurt, or anger. Bouba was calmer and more positive, while cylinders and pyramids had broader, less consistent placements and were often interpreted through action or texture, such as rolling or smoothness, rather than overall form. These results extend established Bouba-Kiki cross-sensory correspondences (Metatla et al. 2019; Roberts-Morgan et al. 2025). **Scents** showed little agreement: each appeared across all four quadrants. Responses were often grounded in hedonic evaluation or personal memories rather than stable emotion mappings. Figure 4 summarises these differences within teams' cross-sensory compositions.

4.2. Association Strategies and Group Dynamics

Familiar experience and sensory features dominated (Figure 5). Familiar references gave groups an accessible starting point: blue became sad through tears, yellow happy through the sun, and objects

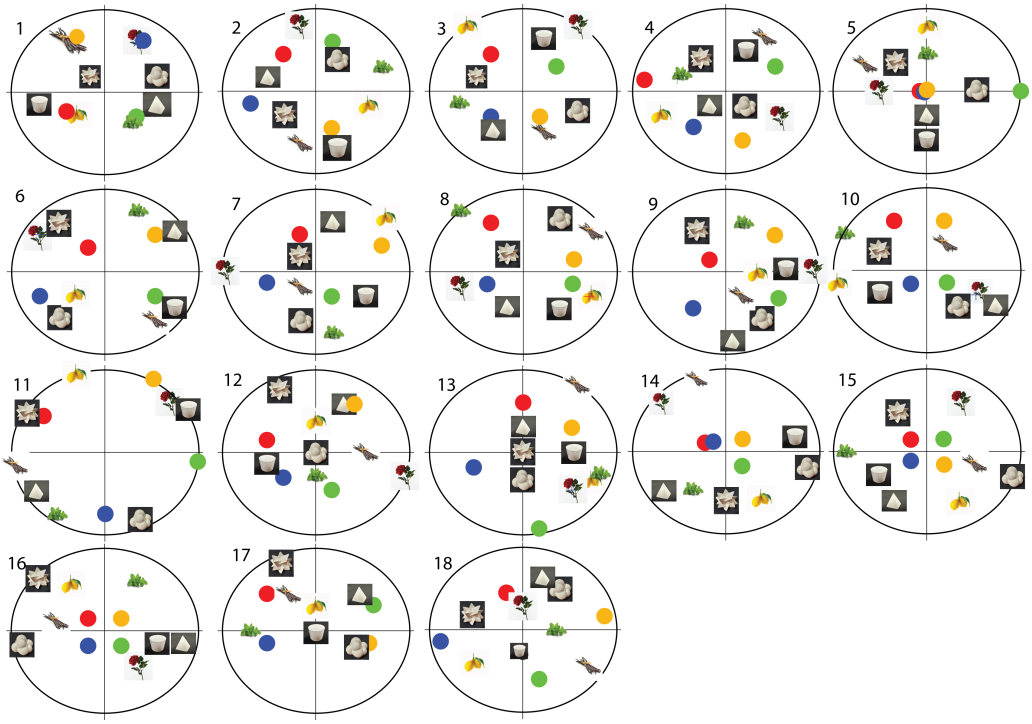
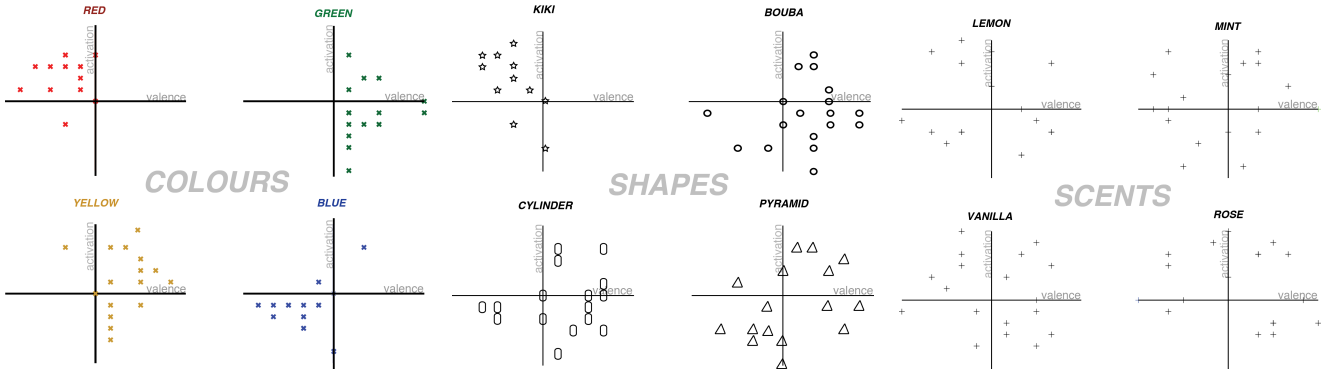


Figure 3: *Team's cross-sensory composition of visual, tactile, and olfactory items by valence (horizontal) and arousal (vertical).*



(a) *Colours* ***(b)*** *Shapes* ***(c)*** *Scents*

Figure 4: *Emotional associations across modalities. Marks represent team placements.*

were linked to known characters or experiences. Sensory features required less common ground because children could jointly attend to visible or tangible properties, especially for shapes, where touch and manipulation let them demonstrate and confirm features. Valence was used most often for scents: children could say whether an odour was pleasant or unpleasant even when they could not identify or describe it. Embodied action was most common for shapes, where gesture and manipulation bridged limited vocabulary and made spatial or affective qualities available to others.

Less frequent strategies mattered when familiar references were unavailable. Personal connections anchored ambiguous items in specific events or relationships, but did not necessarily transfer to others. Internal coherence let groups relate a difficult item to one already placed, using the emerging cross-sensor composition as a resource for later decisions. Each composition thus accumulated a local history, with earlier placements constraining, supporting, or being revised through comparison. Vocalisations occasionally conveyed intensity or texture when descriptive language was insufficient. Across strategies, children moved between memory, comparison, bodily action, and evaluation to make associations available to others.

These differences shaped agreement (Figure 6). Colour proposals were commonly accepted immediately or after brief discussion. Bouba and Kiki produced similarly decisive exchanges because distinctive features supported recognisable interpretations,

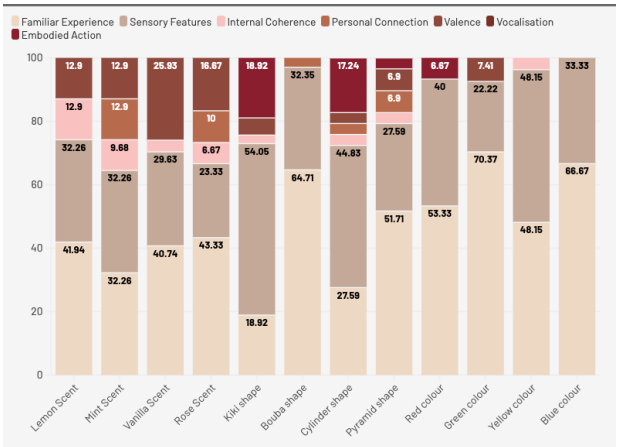


Figure 5: *Association strategies used across 18 teams and 12 sensory items.*

although children often demonstrated these associations through touch and gesture. Scents and neutral shapes more often required persuasion, compromise, or a decision without explicit agreement. When a single scent association was proposed, other children sometimes accepted it with little explicit uptake before the group moved on. Thus an item's inclusion in the completed cross-sensory composition did not always represent shared meaning: some decisions reflected active consensus, while others marked conversational closure under uncertainty.

Brief episodes illustrate how associations became available to groups. A colour association could be compressed into "yellow is happy", requiring little elaboration because peers could draw on a familiar cultural reference. For Kiki, one child explained: "This is very spiky, it feels like anger", moving from tactile exploration to a feature and then an emotional interpretation others could inspect through the same object. A rose scent generated divergent autobiographical anchors: one child linked it to a happy memory of caring for a plant, another to sadness because they had never been given a rose. Resolution therefore depended on how competing personal narratives informed a single placement within the shared composition. Across ambiguous items, we observed both competing accounts and decisions in which one proposal received only minimal verbal uptake before placement. Our episode-level coding therefore supports a distinction between explicit alignment and procedural closure, but does not establish stable individual roles such as "leader" or "quiet participant" across the activity.

5. DISCUSSION

This paper examines how children collectively compose and negotiate emotional meanings across visual, tactile, and olfactory artefacts. As HCI

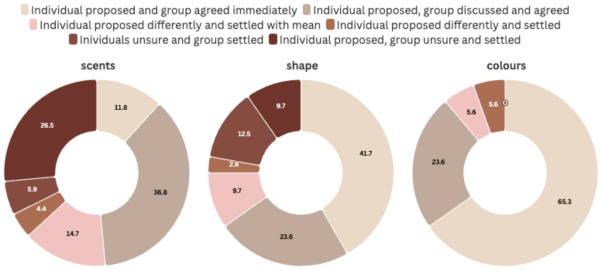


Figure 6: *Distribution of observed group dynamics across sensory items.*

and child-computer interaction increasingly design multisensory technologies for children, the choice and composition of sensory modalities shape how children can express their interpretations, make them available to peers, negotiate differences, and participate in shared emotional communication. We discuss how modality structures collective sense-making, how consensus emerges through composition, and the resulting design implications, before considering limitations and future work.

5.1. Modality Shapes Collective Sense-making

The perceptual and material qualities of the cross-sensory artefacts organised how interpretations became shareable and how the emerging compositions developed. Colours compressed perception and explanation into familiar formulations such as "blue is sad because tears are blue". This enabled efficient alignment, but could limit further exploration by reproducing established cultural scripts (Kumpulainen et al. 2014; Bietti et al. 2019). Shapes invited touching, rotating, rolling, pointing, and imitation (Gallagher and Lindgren 2015; Fuchs and De Jaegher 2009). These actions made claims inspectable and revisable by peers, supporting accounts of touch as relational and generative (Di Paolo and Thompson 2024; Hermans 2022). In this task and cohort, scents exposed limits in shared references for collective sense-making. Olfactory experience can be difficult to verbalise (Herz 2000; Engen 2012), but this does not imply an inherent limitation of smell or children's olfactory competence. The pattern may reflect the fit between the circumplex's English emotion vocabulary, the selected scents, and children's culturally situated experience of discussing odours. Unlike distinctive shapes, scents could not be manipulated to demonstrate a claim; unlike colours, they appeared to have fewer shared scripts linking them to the available emotion terms. Children often shifted to hedonic evaluation or autobiographical memory, and conflicting accounts offered fewer inspectable resources for resolution. Some groups compared scents with colours or shapes already in the emerging composition, using cross-modal translation to re-establish comparison and move forward. These

results complicate consensus as a design objective. The route to a final composition therefore matters for design. Rapid agreement can indicate accessible shared references but may also produce shallow exploration; disagreement can generate richer stories and perspective-taking but may also stall without support. Designers should therefore distinguish between technologies intended for direct emotional communication and those intended for reflection or dialogue. Colours and familiar shapes can support quick expression, while ambiguous scents can prompt personal accounts and negotiation. The latter may need scaffolds such as storytelling prompts, comparison tools, turn-taking roles, or manipulable representations that make otherwise private associations available to others (Morais-Storz et al. 2020; Jiang 2023).

5.2. Consensus as an Interactional Outcome

We observed that consensus could not be inferred from the final cross-sensory composition alone. Equivalent placements within a composition arose through immediate recognition, reasoned alignment, averaging, compromise, or allowing discussion to fade. A system that records only the final arrangement may therefore conceal uncertainty or productive disagreement. Collaborative sensory technologies could preserve the composition process by allowing multiple tokens, brief explanations, confidence markers, or visible alternatives before settlement. This would help distinguish shared interpretation from task completion and preserve emotional expression as an unfolding, interactional accomplishment.

5.3. Design Implications

Cross-sensory systems should support composition through routes that combine rapid expression with elaboration. Legible visual cues can make a proposal immediately recognisable, while manipulable haptic artefacts and shared surfaces can support demonstration, comparison, revision, and the progressive construction of shared artefacts. Ambiguous stimuli can invite memories and disagreement, but require scaffolds - such as storytelling prompts, comparison tools, turn-taking roles, or visible alternative placements - that prioritise mutual understanding over forced consensus (Mehrotra et al. 2022; CASEL 2023). Sense-O-Plex-like activities could therefore inform collaborative games, classroom activities, or installations in which children build cross-sensory compositions that reveal both shared and divergent interpretations, provided that scent-related accessibility and safety are addressed.

5.4. Limitations and Future Work

The study was a short engagement activity with limited demographic information, preventing analysis by age, culture, sensory preference, prior experience, or team relationships. Researcher presence and the progress-oriented format may also have encouraged closure before agreement was complete. Sensory modality was entangled with material form: shapes were three-dimensional and manipulable, scents presented in similar jars, and colours as flat acrylic squares. Differences in composition therefore cannot be attributed to modality alone because manipulability, persistence, and public inspectability also varied. Our episode-level coding identified recurring strategies and routes to placement, but not turn-by-turn gaze, gesture, silence, repair, or sequential organisation. Claims about agreement therefore rely on coded patterns and illustrative cases rather than fine-grained interaction analysis. The twelve artefacts also capture a small design space, and the circumplex may have shaped children's responses. Future studies should examine broader and child-generated stimuli, repeated use, and variation across age and culture, including whether longer deployments support shared sensory vocabularies, ambiguity, and more distributed participation.

6. CONCLUSION

We presented Sense-O-Plex to examine how children reason collectively about emotions through cross-sensory composition. Colours enabled rapid agreement through familiar references, shapes sustained embodied exploration, and scents exposed limits in shared vocabulary and interactional support. Our contribution is an account of how sensory composition organises participation by shaping how children make interpretations visible, negotiate differences, and reach shared or merely settled meanings. For HCI, modality composition structures collaboration and how interpretations become available to others. Cross-sensory technologies for children should combine legible cues with manipulable, revisable representations, preserve alternatives rather than force consensus, and support explanation, comparison, and contestation as shared compositions develop.

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