RTD

Proceedings of the 4th Biennial Research Through Design Conference 19–22/03/2019

Miyoshi, K. 2019. 'Puppetry as an alternative approach to designing kinesthetic movements'. In: Proceedings of the 4th Biennial Research Through Design Conference, 19-22 March 2019, Delft and Rotterdam, The Netherlands, Article 27, 1-16. DOI: https://doi.org/10.6084/m9.figshare.7855802.v1.

Method& Critique *Frictions and Shifts in RTD*

Puppetry As an Alternative Approach to Designing Kinesthetic Movements

Kensho Miyoshi

Royal College of Art, London, UK.
kensho.miyoshi@network.rca.ac.uk

Abstract: 'Kinesthetic empathy' refers to the experience of kinetic sensations of observed movements. It becomes a useful lens for designers to explore the aesthetic quality of the movements of designed objects (e.g. fans, doors, clocks, robots) from an embodied perspective. It also empowers them to imagine and create alternative beings of everyday objects and their movements. In this way, it could eventually lead to rethinking our embodied relationship to the artificial world, especially physical movements of objects and spaces. This paper presents a practice-based research in which four product designers including the author proposed imaginative kinetic products informed by kinesthetic empathy. Rather than moving quickly from ideation to prototyping functional, mechanical motions, our approach was experimental, i.e. we conducted a more flexible and intuitive exploration of movements in collaboration with 'unusual' partners for product designers-puppeteers. The collaborative design process exposed us to unseen benefits and challenges of adopting puppetry as a means to design kinesthetic movements of objects. By bringing together each practitioner's reflection on their design processes and outcomes, the paper concludes by proposing a new design approach to kinesthetic movements that bridges product design and puppetry.

Keywords: kinesthetic empathy, puppetry, movement qualities, everyday objects, kinesthetic design.

Miyoshi | One of the created design model is animated puppeteers. [Kensho Miyoshi].

Introduction

The physical movements of designed objects not only have utilitarian purposes but also allow us to experience diverse sensations of motion. A look at a curtain swaying in the calm wind, for example, can make viewers feel light and relaxed as if they themselves are swaying in the air. By seeing ticket barriers creaking and moving at an awkward speed, one can imagine how it would feel like if their bodies moved in such a manner despite them never being barriers. Such an imaginative projection of one's own embodied sensation onto the external world is called *kinesthetic empathy*. Its origin dates back to 1873, when a German philosopher Robert Vischer used the term *Einfühlung* (later translated into English as *empathy*) to describe the projection of human feeling onto objects and scenery (Vischer 1994). He then pointed out that *Einfühlung* involves kinesthetic reaction. In this context, empathy (or *Einfühlung*) refers to a kind of aesthetic experience while observing non-living objects rather than its modern, widely accepted use which denotes the feelings of others' emotions especially pity and sorrow (Parviainen 2003).

The theory of mirror neurons[1] (e.g. Rizzolatti & Craighero 2004) explains the neurological mechanism of the perceptual phenomenon while other theories such as embodied cognition (e.g. Gibbs 2015) and ecological perception (Gibson 1979) indicate the fundamental connection between observation of the external world and embodiment. Despite Vischer's original implication, the current scholarship on kinesthetic empathy concentrates on the observation of human movements such as the works on dance (Reynolds & Reason 2012) and interaction design (Moen 2006, Fogtmann 2007, Cuykendall et al. 2014, 2015). On the other hand, kinesthetic empathy with the motions of non-living objects remains largely unexplored (Figure 1), except for limited case studies (Ross & Wensveen 2010, Gemeinboeck & Saunders 2015, 2017), and considerably less in relation to design. Given the current trend where movements are increasingly used for aesthetic ends in the field of product design (Yoshimoto 2015, pp.9–22) yet often remain merely decorative, incidental elements that give visual surprise to people, kinesthetic empathy could inform a new approach to the aesthetic potential of movement.

This paper presents an original empirical research that explored the design application of kinesthetic empathy. Four product designers imagined alternative motions of everyday objects and reflected on the design processes, through which new 'knowledge for' (Glanville 2005) design of kinetic objects emerged. The research focused on relatively early stages of design processes such as ideation, creating paper models then full-scale models and exploring movement qualities, not including user testings and manufacturing. The designers referred to a framework called *kinesthetic design framework* which was developed by the author in his prior research (Miyoshi 2018, forthcoming 2019).

My role in the research is threefold: 1) a curator who appoints the team of practitioners and navigates the project, 2) one of the designers who are responsible for the creative exploration by using the framework, and 3) a researcher who communicates new knowledge through reflection and analysis. What follows briefly introduces the design framework then discusses the processes and outcomes of the collaborative project.

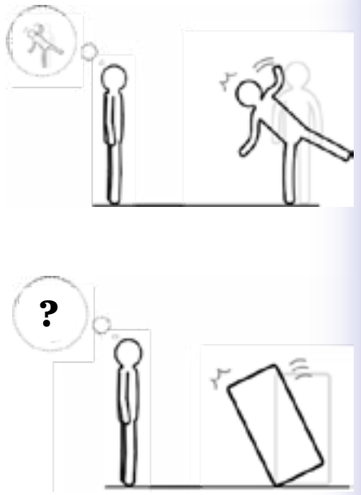
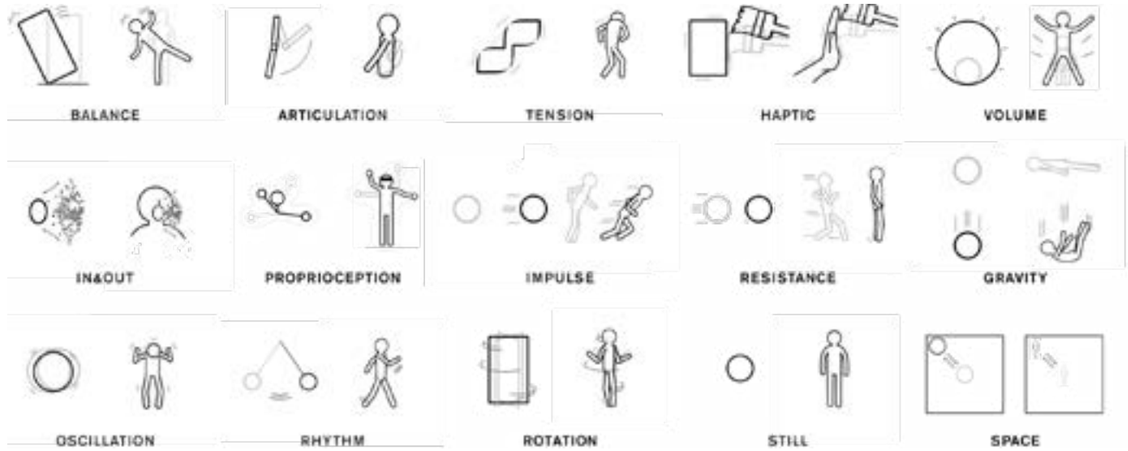


Figure 1a. Kinesthetic empathy with human movements. Observing human movement can allow the observer to internally simulate similar body actions without having to execute them externally.

Figure 1b. Though kinesthetic projection is straightforward when one observes another's bodily motions owing to the kinship between their body structures, relatively ambiguous kinesthetic empathy results from observing movements of non-anthropomorphic objects.

[1] Mirror neurons refer to a specific set of neurons that activate both when one does a particular action and when (s)he observes another individual doing a similar action (Rizzolatti & Craighero, 2004).

Figure 2. *Elliptic Sculpture*, one of the kinetic objects I created with the aim of exploring the kinesthetic potential of object movements. The semi-transparent traces of the object indicates the trajectory and the dynamics of the rocking movement.



Kinesthetic design framework

This design framework was created through my iterative observation of object movements such as kinetic objects I developed (Figure 2), kinetic art sculptures (e.g. Alexander Calder's mobiles) and natural phenomena (e.g. trees moving in the wind). It is comprised of two original concepts: *kinesthetic elements* and *qualitative spectra*. The designers used a web-based motion database called *Kinesthetic Motion Database* (Figure 4), which embodied the framework. The framework supported designers' idea generation as well as post-rationalisation of the ideas conceived intuitively.

Kinesthetic elements

While kinesthetic empathy is experienced differently depending on each observed motion, several commonalities gradually emerged through my observations which I have termed kinesthetic elements. The emergence of the elements was reflective and organic rather than linear and simultaneous—one element served as the lens for me to identify others. Some of the kinesthetic elements were tested in workshops in which designers used them to design kinetic objects. Based on feedback from the participants and references on perception (Bartley 1958, Gibson 1979), embodied cognition (Gibbs 2006), anatomy (Saladin 2010) among others, finally fifteen elements have been identified (Figure 3). The elements are potentially intertwined with each other, not intended to be discrete such as mathematical dimensions.

Qualitative spectra

Kinesthetic elements do not alone reveal the associated general qualities such as intensity (e.g. heavy, light) and emotion (e.g. busy, relaxing). Comprised of multiple spectra each of which has opposite adjectives at the ends—e.g. light/heavy, awkward/smooth and intrinsic/extrinsic, qualitative spectra support further articulation of motion qualities. They were inspired by the movement analysis system called *Effort/Shape* developed by dance theorists Rudolf Laban and Irmgard Bartenieff (Bartenieff 1980), where three criteria—weight, time and space—are expressed as continuums between two opposing ends (e.g. light/strong of weight). A recent study on anthropomorphism of moving objects (Wolf & Wiggins 2018) provided a further reference with regard to the variety of spectra potentially relevant to kinesthetic empathy.

Figure 3. Fifteen kinesthetic elements. For each element, the human movements on the right represent the body movements that might produce the kinesthetic sensation projected onto the object movements illustrated on the left. Kinesthetic elements are concerned with the 'internal' experiential qualities rather than the 'external', visual representation of movements. See (Miyoshi 2018, 2019) for the origins of the elements.

Figure 4. One of the pages of the Kinesthetic Motion Database (created by the author), presenting the *balance* element. Each object movement (left) is accompanied by a human body movement (right) and comments to describe how each object motion is kinesthetically empathic. The database has been created as an embodiment of kinesthetic design framework as well as a tool for designers to familiarise themselves with the concept of kinesthetic empathy and its applicability to designing objects.

Collaborative project

The collaborative project this paper centres on was aimed at overcoming a defect of the workshops conducted previously. Kinesthetic design framework successfully provided a guideline for designers' ideation of imaginative kinetic products. Yet, the design ideas generated were presented merely as annotated sketches (Figure 5a) or small-scale rough models (Figure 5b) at best within the limited timeframe. Without physical movements, it was difficult to properly examine if the motions the designers conceived would allow us to perceive the intended kinesthetic responses. The objective of this research was to conduct an extended practical exploration by producing physical full-scale models and experimenting with actual movements.

To this end, one may naturally think of the method of prototyping—the creation of physical models that are capable of testing the intended movements and functions (Hanington & Martin 2012, p.138). As I knew from my prior research and my educational background in engineering, however, it was expected to be challenging and costly to prototype mechanical, especially self-actuated, movements with high accuracy in subtle nuances. To avoid this probable risk and allow for a more flexible and exploratory approach, I considered an experimental partnership with puppeteers.

Puppetry as design exploration

Almost one year before this project began, I interviewed a professional puppeteer, Rachel Warr, and came to understand her comprehensive knowledge of puppetry, staging and movements. She also gave me a quick demonstration of puppetry, animating a random piece of paper that happened to be on my desk. The way in which she expressed diverse qualities in the motion was highly impressive. This experience was recalled and connected to my research when I was planning how to proceed with it. The initial consultation with her indicated her great openness for experimental projects such as this research, which gave me intuitive confidence to follow this exploratory direction.

The expected value of collaborating with puppeteers was threefold. First, in puppetry, the body of the performers becomes the 'actuators' of the objects, which would enable intuitive and flexible exploration of the subtle nuances of movements. Without the need for rebuilding mechanical structures or rewriting programmes, the rapid iteration of testing motions could be possible. Second, puppetry could broaden the possibility of design ideation by removing the constraints of time and technological resources. Third, the puppeteer's knowledge and repertoire of movements could assist designers' exploration of the movement qualities.

Team

The collaborative team consists of the following nine members (Figure 6): two puppeteers; three other product designers who had previously participated in one of my prior workshops and were already familiar with my research; sound designer who is experienced in Foley technique and was responsible for creating sound of the designed objects; actor Mark Esaias, who played the role of the user of the designed objects; videographer Kumi Oda, and me. Full credits appear at the end of the paper.

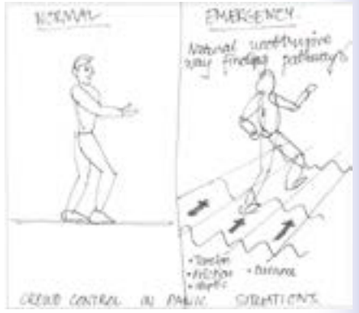


Figure 5a. One of the design ideas generated by the workshop participants titled *Crowd Control in Panic Situations*. The annotated sketch shows the use scenario in which a transformable carpet creates wave patterns that visualise the route for evacuation. The transformation, quick contracting of the fabric, is intended to make people kinesthetically empathise with the sense of tension and emergency.

Figure 5b. The small-scale rough models that demonstrate the idea. The wave-shaped fabric represents the designed carpet in emergency and the hand and fingers the people walking along the wave on the carpet.

Design process

Instead of creating functional prototypes, we aimed to create full-scale models and present their imaginative movements and use scenarios in a short film. It was created as a tool for the designers themselves to watch, explore the gap between their intention and what is performed by the puppeteers and reflect on the design process. The puppeteers and the rods they used to animate objects were erased in the postprocedure so that the objects would appear in the short film as if they were moving stand-alone.

This puppetry-informed approach is related to the Wizard of Oz technique 'in which participants are led to believe they are interacting with a working prototype of a system, but in reality, a researcher is acting as a proxy for the system behind the scenes' (Hanington & Martin 2012, p.204). The essential difference lies in the type of audience—in Wizard of Oz method it is the participants in the experiments, but in this study the designers themselves.

Ideation and design criteria

Two criteria for design emerged through the ideation, discussing potential ideas to pursue further. One was concerned with the degree of anthropomorphism.[2] Whereas human-like objects easily evoke kinesthetic empathy, excessive use of anthropomorphic appearance might distract from the use and deteriorate the aesthetics of objects. We became aware of this during the ideation then started to pursue the object movements that are abstract (not explicitly human-like), yet kinesthetic. The other criterion was related to the role of motion in the designed objects. Kinetic artist George Rickey (1963) called kinetic sculptures in which motions and forms are fully integrated (e.g. Alexander Calder's mobiles) as 'movement itself', and regarded such works as 'valid achievements' as art objects. Likewise, we aimed to design movements that are linked with the functions or use scenarios of the objects in some way rather than forcibly adding motions that are merely accessory and relevant to neither their functions nor contexts.

Puppetry

The puppeteer offered a brief introduction to puppetry techniques and her underlying thoughts to the designers at the beginning of the project. Once the designers have produced paper models, she provided more concrete consultation on how the movements designers intended could be realised in puppetry.

Video shooting and editing

Seven products were finally designed and filmed along a story of an office worker's weekday in London from the morning to the evening. This scenario eventually emerged out of the created design ideas. The sound designer created the sound of the products, the actor's behaviours and the environment.

Reflective interview

After the video editing was completed, I interviewed the product designers and the puppeteer individually in order to understand their experiences, learnings and reflection. The edited film was presented to them and they answered a couple of questions related to the design processes and outcomes.

The following text details four imaginative products designed.

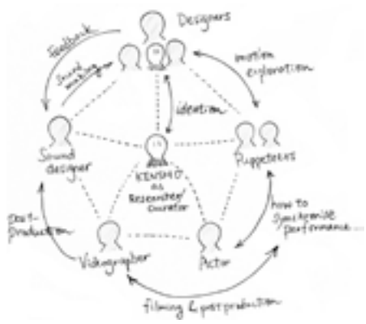


Figure 6. The structure and dynamics of the collaborative team. The value and role of the puppeteers were as follows. Rachel Warr (one of the puppeteers) aided the designers' exploration into kinetic design ideas not only by asking questions but also providing suggestions around the details of the motion which designers could be overlooking. It seems that the designers were more focused on the highlight of the products' movements (especially when they serve the main functions) whereas the puppeteer helped them expand the designers' perspectives by pointing out the peripheral such as the movements 'before' and 'after' the products complete their main functions (e.g. how objects turn off, if they show any physical motions when activated). Beyond such consultancy, they can also physically demonstrate motions of a variety of expressions, which allows the designers to broaden their perspectives on their current ideas as well as potential alternatives.

[2] In this paper, anthropomorphism is defined as the attribution of human characteristics such as appearance, intention and emotion especially to non-living objects. The degree of anthropomorphism is affected by the static appearance and the movement of an object in a complex manner. Even a completely abstract-looking object could indicate anthropomorphism depending on its movement whereas an object with human-like appearance might be rendered less anthropomorphic by its movement.

<Figure 7. A full-scale model of *Breathing Humidifier* created by one of the product designer, Anne Zhou, and animated by puppeteers. The vapour accumulated inside is emitted through the small hole on the upper right of its body. The dent on the upper left of the cover indicates the slight deflation of the humidifier.

Breathing Humidifier

Breathing Humidifier was designed by focusing on the kinesthetic sensations related to breath. Made of a silicone cover with a small hole on it and a wooden base, the humidifier inflates and deflates akin to a lung inhaling and exhaling (Figure 7). Water is vaporised and filled inside the flexible cover and emitted outside as the cover deflates and increases the internal pressure. Then the cover inflates again and refills the vapour inside. By repeating this, the humidifier is supposed to diffuse the vapour into the surrounding space (Figure 10).

The continuous repetition of the inflation and deflation invite people to kinesthetically empathise with the rhythm of the expansion and shrinking. The kinesthetic empathy could remain even when the eyes are closed because of the subtle sound of the humidifier. The kinesthetic potential of the humidifier's movement can be explained with the kinesthetic elements of *rhythm*, *volume*, and *in&out*. *Rhythm* derives from the repetition of inflation and deflation; *volume* from the volumetric change of the cover; *in&out* from the cover emitting vapour and sucking air. Since the motion of the humidifier can be easily associated with that of human lungs, it would easily evoke kinesthetic empathy. On the other hand, expansion and shrinking could potentially make the object appear to be some unknown creature, which was not the designer's intention. Being aware of this risk, she explored the size and forms that can escape an excessive anthropomorphic or zoomorphic attribution without losing the kinesthetic potential (Figure 8).

In the film, the actor expressed the kinesthetic empathy with the humidifier by synchronising his breath with the inflation and deflation of the humidifier (Figure 9). The objects were animated by two puppeteers; one controlled the cover's motion by pulling the string attached to the internal surface of the silicon cover and the other controlled the fluid of mist synchronously with the inflation and deflation.

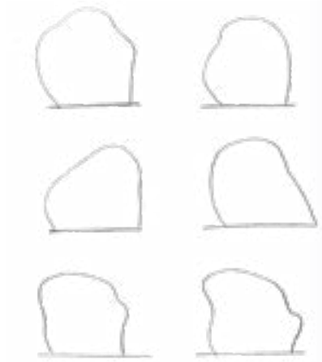


Figure 8. Part of the sketch by the designer exploring the form between abstract and anthropomorphic. Image credit: Anne Zhou.

Figure 9. *Breathing Humidifier* is intended to be used in bedrooms, allowing people to perceive the sense of relaxed, deep breath.

Figure 10. The sequence of the movement of *Breathing Humidifier*, from deflation to inflation (from left to right).

<Figure 11. *Obnoxious and Courteous Barriers* (the same setting was used for both barriers and the same actor played both passengers separately which was combined in the postproduction). The discomfort of going through ticket barriers partly derives from the potential physical contact with the moving barriers (e.g. the barriers might hit you unexpectedly) which concerns affordance rather than kinesthetic empathy. But this is not the focus of this design.

Obnoxious and Courteous Ticket Barriers

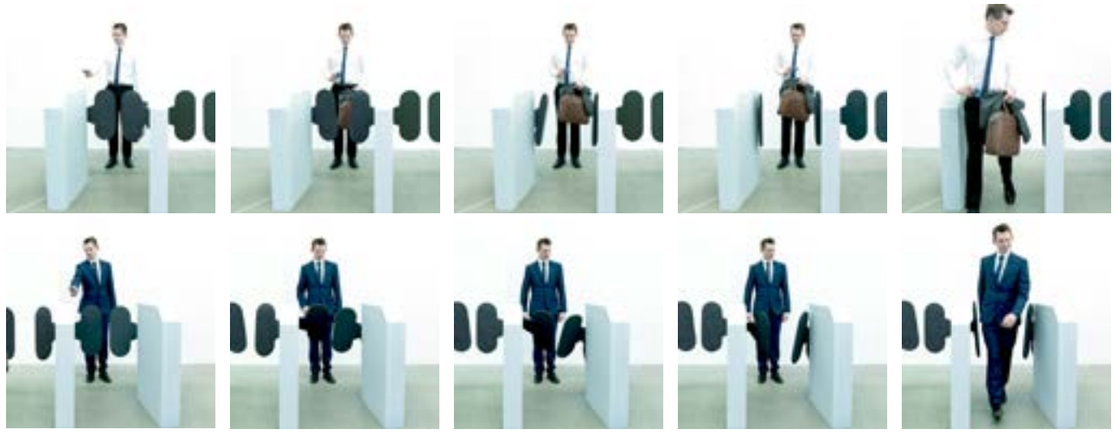
As a designer, I explored alternative motions of ticket barriers. The two sets of barriers allow viewers to perceive distinct movement qualities whilst sharing the same structures. *Obnoxious Barriers* (Figure 11, left) move at an awkward speed, creak heavily and finally slam the machines and make the bang sound (Figure 13a). *Courteous Barriers* (Figure 11, right), in contrast, have more gestural and graceful quality. The upper ends of the barriers move first and tilt forward then the lower ends move slightly later. As a result, the barriers follow a curvilinear path as Figure 13b illustrates, making little sound. The smooth up and down, acceleration and deceleration could remind of the dynamic yet elegant kinesthetic feeling of the steps in dancing waltz. The former is a slight exaggeration of my own experience in London Underground stations whereas the latter indicates its desirable alternative, which minor changes in the dynamics and the mechanisms could possibly achieve.

Both movements are associated with the *impulse* (sense of acceleration) and *resistance* (deceleration) elements although they consequently take on opposite qualities. The *haptic* element is present in the creaking sound of *Obnoxious Barriers* that allows us to perceive the internal frictions and materiality. The *gravity* element is present in the waltz step-like motion of *Courteous Barriers*.

The actor expressed two kinds of kinesthetic empathy through his reactions—shivering back and walking lightly (Figure 13a, b). The pair of puppeteers held and moved each of the barriers (Figure 12).

Figure 12. The puppeteers performing *Courteous Barriers*. They were erased in the postproduction of the film which finally looks like Figure 11.

Figure 13a, b. The sequence of the movement of a) *Obnoxious Barriers* and b) *Courteous Barriers* (from left to right). The movement of the latter may look complicated but, it could be realised by adding one motor, or one degree of freedom of movement, that allows the vertical pivoting.



<Figure 14. The 3D-printed design model of *Flying Cork Opener* (left) and the champagne bottle with a cork (right), designed by Ruijing (Hazel) Yan. To enable the propeller to spin by itself, a rubber ring is attached to it and placed inside the axis.

Flying Cork Opener

While some of the kinesthetic motions designed in this project can be easily associated with human movements (e.g. *Breathing Humidifier*), one of the product designers was interested in seeking implicit connections to our behaviours. She initially conceived a flying bottle cap for PET bottles (Figure 15), but later transformed it into *Flying Cork Opener*, a cork opener for champagne bottles (Figure 14). It consists of a propeller and an axis that is inserted into a cork. As the propeller is screwed, the attached coil (inside the axis) accumulates tension which is then released and creates the thrust (Figure 17). Using the lift of the rotating propeller and the pressure of the champagne gas, the cork flies up with the opener.

The kinesthetic empathy evoked by *Flying Cork Opener* is not intended to connect to specific bodily movements. Instead, it is meant to stimulate the basic fragments of our embodied sensation such as the senses of energy and direction. The movement is intended to enhance the mood in the parties and amplifies the senses of joy and excitement.

The way in which the movement intuitively triggers people's kinesthetic empathy can be broken down into the following three elements although people would not instantly analyse these motion elements in the actual scenarios. The rocketing of the opener stimulates the sense of *impulse* (from stability to rapid ascend) and *gravity* (the power to move against the gravity). The swift spinning of the propeller has the *rotation* element.

A rod attached to the cork opener was used to animate the flight of the cork opener (Figure 16). For the purpose of revealing the kinesthetic potential of the object movement, the actor slightly overly expressed the experience of kinesthetic empathy. The short film was created to depict the way in which the spinning of the propeller 'infects' people in a home party who then start spinning likewise and dancing.

Figure 15. Concept sketch of *Flying Cork Opener*. Image credit: Ruijing (Hazel) Yan.

Figure 16. The puppeteer moved the cork via the attached yellow-green rod.

Figure 17. The sequence of the movement of *Flying Cork Opener*, from being screwed to flying.

<Figure 18. The design model of *Curling Bed Lamp*, designed by Viraj Joshi, placed on a bedside cabinet. The short film depicts a situation where the person is already accustomed to the lamp's behaviour; he can kinesthetically empathise with it even without looking at it perhaps just by hearing the lamp curling. The lamp might appear as if reacting to the person's curling but our intention differs. What matters here is that they happen *almost* simultaneously, not in a strict order (e.g. human then lamp, or vice versa).

Curling Bed Lamp

One of the designers focused on a unique sensation of comfort, warmth and protection experienced while cocooning in a duvet, and transformed it into a kinetic bedside lamp (Figure 19). *Curling Bed Lamp* (Figure 18) has an onion-shaped lampshade made of flexible cloth that controls the brightness by curling and uncurling (Figure 20v-viii). The curling movement of the lamp is intended to allow people to rediscover and enhance their unnoticed embodied sensation. In this design, the movement, function and context are integrated in a successful manner. The curling of the lamp can be associated with the bodily sensation in bed because of the context; if the same object is put in different places such as supermarkets, classrooms and bathrooms, the motion would be linked with other kinds of kinesthetic sensations. The movement of the lampshade is intended to be self-actuated, responding to the person's behaviour, in the case of the film, putting a book near the lamp (Figure 20i-iv).

The elements of *tension*, *haptic*, *volume* and *rotation* are present. *Tension* can be perceived in the elastic transformation of the lampshade. The contraction of the lampshade makes viewers perceive the *haptic* element from the fabrics of the lampshade touching each other as well as the *volume* from the shrinking. The gentle twist of the structure creates a subtle sense of *rotation*.

The design model was animated by using a rod attached to the lampshade (see the cover image). It was erased in the postproduction process.

Figure 19. Concept sketch of the 'kinesthetic' design ideas drawn by the designer. *Curling Bed Lamp* (in the middle, toward the bottom) was originally conceived as a lamp with the spiral-shaped lampshade. Image credit: Viraj Joshi.

Figure 20i-viii. The use scenario of *Curling Bed Lamp*. The actor puts the book on the bedside lamp (ii) and wraps himself in the duvet (v-vii).

Reflection and learnings

Informed by the methodology of reflective practice (Schön 1983), research through design (Frayling 1993), also referred to as research through practitioner action (Archer 1995), I sought through reflection for the new learnings that the project provided. I interviewed the designers and puppeteer about their reflection on the design processes and outcomes. The interviews were initiated with the following questions and the rest of the dialogue was conducted freely as far as the topic was relevant:

1. What was the challenge of this collaborative project for you?
2. What did you learn from the project?
3. Did you experience any change in your perception of movements through and after the project?

The members' reflection, as well as mine, are summarised into the following six themes.

Puppetry and feasibility

The introduction of puppetry as a means of design exploration brings freedom from the technological implementation which assisted designers to bring their ideas beyond orthodoxy. At the same time, we had to carefully consider the realistic-fictional balance of the project since even wizardry could be performed in the world of puppetry. It was my decision as a curator and a researcher to pursue the realistic and feasible realm rather than dreaming a completely fictional world. This is because a completely fictional phenomenon, because of its peculiarity, might dominate the impression of the objects where the aesthetics explored with kinesthetic empathy could be too subtle to be sufficiently examined.

Anthropomorphism vs kinesthetic empathy

The preferred balance between anthropomorphism and kinesthetic empathy was ambiguous when the project started, which the designers mentioned as the main challenge. The design criterion 'abstract yet kinesthetic' emerged out of such needs for clarity in the direction. Still, there was a freedom for designers (within the same direction) in terms of the balance between explicit and implicit similarity to human movements as Figure 21 indicates. The knowledge of such spectrum inspired me as a designer to conceive *Obnoxious and Courteous Ticket Barriers*, where two movements have different degrees of human-likeliness yet both are kinesthetic.

What makes such gradient possible? It is an interesting feature of kinesthetic empathy that the kinesthetic aspect of the movements is likely to be noticeable to the people who are in, or familiar with, the similar kinesthetic conditions (Calvo-Merino et al. 2006; Blakeslee & Blakeslee 2007, p.135; McGarry & Russo 2011). It is as if one 'mirrors' observed object motions they know well in a kinesthetic and spontaneous manner. Therefore, a movement could appear kinesthetic enough for observers in certain situations even without explicit human-likeliness in itself. Such 'subtle yet noticeable (for people in certain situations)' feature of kinesthetic empathy will turn the contexts of objects into a new clue to triggering such a kinesthetic 'mirroring'. Further, that kinesthetic empathy does not require explicit an human-like appearance in the object enables to create abstractness or space onto which people can project themselves thus empathise with.

Figure 20. The mapping of the four des1gn examples on the spectrum between explicit and implicit connection to human movements.

The puppeteer, from her own experience, had already well recognised the problem of anthropomorphisms and helped us articulate it. She pointed out the human tendency to seek their status in relation to anthropomorphic objects such as hierarchy and the level of intelligence. We inherently feel responsible for human-like objects because, for example, they are smaller than us, limited in its capability or because we have more knowledge than them.

Integration of motion, function and kinesthetic empathy

Adopting Rickey's 'movement itself' concept, we pursued the integration of movements, their functionality and kinesthetic potential, which is successfully embodied in the presented four designs. However, behind them was an iterative process of ideation although the design framework did provide a basic direction. Most of the kinetic everyday objects are optimised for functionality. The challenge was to explore kinesthetic aspects without completely untying the connection between motions and functions.

Encounter with the 'right' movement

Once the paper models were created, the puppeteer and the designers explored together potential ways to animate the models. While watching the puppeteer exploring motions with her hands (Figure 22), each designer including myself found the exact movements we had in mind, yet had not been able to articulate. Such moments were not only joyous but also confirmed that we have reached the specific, satisfactory quality of movement if largely non-verbal. In order to make the exploration of motion qualities effective, the puppeteer emphasised the importance of free, playful, and even silly exploration when they first encounter objects (Figure 23).

Figure 22. The puppeteer is testing the puppeteer-ability of the paper model presented by one of the product designers.

Creating design models for puppetry

It was uncertain at the beginning of the project how to create 'puppeteer-friendly' product models. The designers stated that it did not become a challenge or was even much easier than creating electromechanical prototypes. On the other hand, however, the puppeteer pointed out that some of the models were difficult to animate. For example, the ticket barriers could have been animated more easily with some support tools or mechanisms that could guide the trajectory of the barriers. This gap is the result of the limited time and opportunities for mutual understanding during the design processes, which is to be resolved in the future practice and research.

Figure 23. The puppeteer holding a carbon fibre rod and posing while exploring the materiality of the rod. The rod was used for another object which is not introduced in this paper. She emphasised that much can be learnt from finding the extremes through such actions, which helps puppeteers finally specify movement. This remark also supports the value of qualitative spectra of the kinesthetic design framework.

Sound

The puppetry-informed exploration was, on the one hand, beneficial in that designers could focus on the concrete nuances of movement from the early stages. On the other hand, there was a risk that too much focus was put on motion and less on the material nature of objects. Collaboration with the sound designer counterbalanced the attention as it allowed the designers to examine in depth the materials and structures through thinking how the objects ought to sound. Eventually, some sounds were created as realistic while others less so but as an indication of the desirable sense of dynamics and materiality. All sounds are 'consequential' sounds (results of 'operating and construction') rather than 'intentional' sound (more artificial sound signifies some meanings e.g. 'beep' sound) (Langeveld et al. 2013).

From Studio to Method

The result of the research is largely dependent on the individual practitioners and the context of the collaboration and therefore difficult to generalise. Nevertheless, it has touched on the benefits and challenges of adopting puppetry as a means to design kinesthetic movements of objects. What is discovered here is a seed of vast, rich and relatively unexplored design approach that bridges product design and puppetry.

Why puppetry and puppeteers?

The puppeteers, with a rich repertoire of movements and skills to demonstrate them, significantly assisted the designers' exploration of motion qualities. Compared to other types of motion-related creative professions such as animation design and dance, puppetry is more directly compatible with the process in which product designers work with tangible materials. While the technique of puppetry harnessed in the study is limited (rods and directly with hands), other formats such as shadow and wire puppetry would potentially allow different angles of explorations.

Puppetry-compatible design models

Both designers and puppeteers agreed that the physical objects were vital for their exploration of movements. Given the feedback from the puppeteer, it would be beneficial for designers to create not only the design models themselves but also certain mechanisms and tools that could assist puppeteers to explore movements even if they are not part of the intended designs.

Development of shared tools and vocabulary

The reflective interview I conducted revealed commonalities and gaps between the designers' and puppeteer's views. Although, in this study, I mediated their perspectives as a researcher, their collaboration would be more effective by developing common tools and vocabulary through sharing their reflections further. The playful exploration that the puppeteer mentioned is an example of useful tools that could promote the collaborative exploration.

Conclusion

Based on the kinesthetic design framework, four product designers including me explored alternative movements of everyday objects in collaboration with puppeteers, 'unusual' partners in product design. The four design outcomes demonstrate how kinesthetic motions could be employed in everyday objects. The design process exposed the team to unseen benefits and issues of the puppetry-informed approach. The designers not only created successful applications of the design framework but also acquired the kinesthetic sensitivity to movements progressively through their exploration and exchange with the puppeteers and sound designer. My three roles in the project also informed me of the concrete situations and atmosphere of each design process and affected the way in which I designed kinesthetic movements. Overall, this paper has laid out the original design practice and the practitioners' reflection on it, out of which I confirmed the high potential in the puppetry-informed approach to designing kinesthetic motions. Although product design and puppetry have not intersected actively so far, I hope to have made clear that puppetry could be beneficial to, and also unexpectedly compatible with, part of the process of designing kinetic objects.

Acknowledgement

I would like to especially thank the following creative practitioners, without whom the research would not have been possible: Rachel Warr and Tom Crame, puppetry; Anne Zhou, Ruijing (Hazel) Yan and Viraj Joshi, product design; Yaprak Göker, sound design; Mark Esaias, acting; Kumi Oda, filming and editing; Pengduowen Li, photography.

This research was conducted as part of the author's doctoral research at the Royal College of Art which was supported by Nakajima Foundation and Terumo Foundation for Life Sciences and Arts.

References

Archer, L.B. (1995). The Nature of Research. *Co-design, interdisciplinary journal of design*, 2(11), pp.6–13.

Bartenieff, I. (1980). *Body movement: coping with the environment*. Reading: Gordon and Breach Science Publishers.

Bartley, S. H. (1958). *Principles of perception*. New York: Harper Bros.

Blakeslee, S., & Blakeslee, M. (2007). *The body has a mind of its own: How body maps in your brain help you do (almost) everything better*. New York: Random House.

Calvo-Merino, B., Grèzes, J., Glaser, D. E., Passingham, R. E., & Haggard, P. (2006). Seeing or doing? Influence of visual and motor familiarity in action observation. *Current biology, 16*(19), pp.1905-1910.

Cuykendall, S., et al. (2014). Designing interaction categories for kinesthetic empathy: A case study of synchronous objects. In: *Proceedings of the 2014 International Workshop on Movement and Computing*, Paris, 16-17 June 2014, New York: ACM Press, pp.13-18.

Cuykendall, S., et al. (2015). Simply spinning: Extending current design frameworks for kinesthetic empathy. In: *Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction*, Stanford, CA, 16-19 January 2015, New York: ACM Press, pp.305-312.

Fogtmann, M. H. (2007). Kinesthetic empathy interaction–exploring the possibilities of psychomotor abilities in interaction design. In: *Second International Workshop on Physicality*, Lancaster, 2-3 September 2017, pp.37-41.

Frayling, C. (1993). Research in Art and Design. *Royal College of Art and Design Papers*, 1(1), pp.1-5.

Gemeinboeck, P., & Saunders, R. (2015). Towards socializing non-anthropomorphic robots by harnessing dancers' kinesthetic awareness. In: *International Workshop in Cultural Robotics*, Springer, Cham, pp.85-97.

Gemeinboeck, P., & Saunders, R. (2017). Movement Matters: How a Robot Becomes Body. In: *Proceedings of the 4th International Conference on Movement Computing*, London, 28-30 June 2017, Article No. 8.

Gibbs Jr, R. W. (2006). *Embodiment and cognitive science*. Cambridge; New York: Cambridge University Press.

Gibson, J.J. (1979). *The ecological approach to visual perception*. Boston: Houghton Mifflin.

Glanville, R. (2005). A (cybernetic) musing: Certain propositions concerning prepositions. *Cybernetics & Human Knowing*, 12(3), p.87-95.

Hanington, B., & Martin, B. (2012). *Universal methods of design: 100 ways to research complex problems, develop innovative ideas, and design effective solutions*. Beverly, MA: Rockport Publishers.

Jahoda, G. (2005). Theodor Lipps and the shift from "sympathy" to "empathy". *Journal of the History of the Behavioral Sciences*, 41(2), 151-163.

Ju, W., & Takayama, L. (2009). Approachability: How people interpret automatic door movement as gesture. *International Journal of Design, 3*(2), pp.1-10.

Langeveld, L., van Egmond, R., Jansen, R., & Özcan, E. (2013). Product sound design: Intentional and consequential sounds. In: *Advances in industrial design engineering*. InTech.

Martin, J. (1939). *Introduction to the dance*. New York: Norton.

McGarry, L. M., & Russo, F. A. (2011). Mirroring in dance/movement therapy: Potential mechanisms behind empathy enhancement. *The Arts in Psychotherapy, 38*(3), 178-184.

Miyoshi, K. (2018). *Where kinesthetic empathy meets kinetic design*. In Proceedings of the 5th International Conference on Movement and Computing. ACM, Article no. 32.

Miyoshi, K. (forthcoming 2019). What allows us to kinesthetically empathize with motions of non-anthropomorphic objects? *Journal of Somaesthetics*.

Moen, J. (2006). *KinAesthetic movement interaction: designing for the pleasure of motion* Doctoral dissertation, KTH Royal Institute of Technology.

Parviainen, J. (2003). Kinaesthetic empathy. In: *Dialogue and Universalism 13* (11-12), pp.151-162.

Reynolds, D., & Reason, M. (Eds.). (2012). *Kinesthetic empathy in creative and cultural practices*. Bristol, UK; Chicago: Intellect.

Rickey, G. W. (1963). The morphology of movement: a study of kinetic art. *Art Journal*, 22(4), pp.220-231.

Rizzolatti, G., & Craighero, L. (2004). The mirror-neuron system. *Annu. Rev. Neurosci.*, 27, pp.169-192.

Ross, P. R., & Wensveen, S. A. (2010). Designing aesthetics of behavior in interaction: Using aesthetic experience as a mechanism for design. *International Journal of Design*, 4(2), pp.3-13.

Saladin, K.S. (2010). *Anatomy & physiology: the unity of form and function*. Dubuque: McGraw-Hill.

Schön, D.A. (1983). *The reflective practitioner: How professionals think in action*. Farnham: Ashgate Publishing Limited.

Vischer, R. (1994). On the optical sense of form: A contribution to aesthetics. Empathy, form, and space: problems in German aesthetics. In: Kostman, L., (Ed., Trans.) [1873] *Empathy, form, and space: problems in German aesthetics*. Santa Monica, CA: Getty Center for the History of Art and the Humanities, pp.89–124.

Wolf, O. O., & Wiggins, G. (2018). Look! It's moving! Is it alive? How movement affects humans' affinity to living and non-living entities. *IEEE Transactions on Affective Computing*.

Yoshimoto, H. (2015). *Pulse and rhythm: exploring the value of repetitive motion as an element of design*. Doctoral dissertation, Royal College of Art.