CHOREOGRAPHIC INSCRIPTIONS: A FRAMEWORK FOR EXPLORING SOCIOMATERIAL INFLUENCES ON QUALITIES OF MOVEMENT FOR HCI

Lian Loke
Design Lab
University of Sydney
Australia

A. Baki Kocaballi
Design Lab
University of Sydney
Australia

Abstract: *With the rise of ubiquitous computing technologies in everyday life, the daily actions of people are becoming ever more choreographed by the interactions available through technology. By combining the notion of inscriptions from actor–network theory and the qualitative descriptors of movement from Laban movement analysis, an analytic framework is proposed for exploring how the interplay of material and social inscriptions gives rise to movement patterns and behaviors, translated into choreographic inscriptions described with Laban effort and shape. It is demonstrated through a case study of an affective gesture mobile device. The framework provides an understanding of (a) how movement qualities are shaped by social and material inscriptions, (b) how the relative strength of inscriptions on movements may change according to different settings and user appropriation over time, and (c) how transforming inscriptions by design across different mediums can generate action spaces with varying degrees of openness.*

Keywords: *choreographic inscription, movement quality, actor–network theory, Laban movement analysis.*

INTRODUCTION

Everyday actions of people are becoming ever more choreographed by the interactions available through ubiquitous computing technologies. As these technologies become embedded in objects and the environment, close to the entire range of human actions, movements and gestures that make up daily life become available for input and computational processing. This poses a challenge to the fields of human–computer interaction (HCI) and interaction design. HCI now has specializations such as tangible, natural, and proximal interaction that include an explicit movement dimension. But when is movement a design priority in itself? Most applications require some form of human movement to take place for interaction but often in the service of achieving a goal or task that is not explicitly about movement itself. In recent years, applications have appeared where movement is the central focus of the system, often for games, sport, dance, exercise, and rehabilitation. Even if movement is not the central or explicit focus of the system, the fact that movement is involved at some level to facilitate actions and interactions with and through technology brings a new significance to the quality and spectrum of movements people perform in daily life.

We are interested in examining how material and social factors enable or constrain movement patterns and behavior, whether intentionally by design or as a side-effect. In this paper, we propose to do this through an analysis combining actor–network theory and Laban movement analysis. Our focus goes beyond functional movements to consider the quality, expressivity, creativity, and kinesthetics of movement often treated as choreographic in nature. By combining the notion of inscriptions from actor–network theory and the qualitative descriptors of movement from Laban movement analysis, a new concept for HCI, *choreographic inscriptions*, is put forward for inscribing qualities of movement by design.

The notion of inscriptions is often employed together with that of translations. In very simple terms, they correspond to acts of writing and reading, respectively. They are key terms of actor–network theory (Akrich & Latour, 1992) to render visible the interconnectedness between entities and transformations taking place at multiple levels during interactions between entities. While acts of inscribing onto something generate various programs for action, acts of translating something may produce deviations from the inscribed programs for action. Therefore, as Hanseth and Monteiro asserted, the notion of inscription allows a balance between technological and social determinism:

> Balancing the tight-rope between, on the one hand, an objectivistic stance where artefacts determine the use and, on the other hand, a subjectivistic stance holding that an artefact is always interpreted and appropriated flexibly, the notion of an inscription may be used to describe how concrete anticipations and restrictions of future patterns of use are involved in the development and use of a technology. (Hanseth & Monteiro, 1997, p. 3)

The notion of choreographic inscriptions aims to provide a way of framing and conceptualizing human movement beyond the purely functional towards an understanding of the field of potential movement quality and expression enabled or constrained through designed artifacts and the social world in which they are embedded. The term *choreography* is traditionally defined as the composition or structuring of movement in space and time (Butterworth & Wildschut, 2009). It also speaks to the aesthetic, creative, and vitality-generating aspects of movement (Fraleigh, 1987), the qualities that foster a more nuanced and

articulate human movement expression and quality of life. In etymological terms, choreography is writing dance or, as anthropologists more broadly define it, "writing movement" (Williams & Farnell, 1990). Choreography has been understood as inscribing moving bodies in space (Martin, 1995) and, by extension, into other media, including digital technologies (Lycouris, 2009). The transfer of choreographic thinking onto materials other than the body can be considered a form of inscription (in the actor–network theory sense of creating programs of action), echoing Forsythe's (2009) contention that "A choreographic object is not a substitute for the body, but rather an alternative site for the understanding of *potential instigation and organization of action* to reside" (p. 4; emphasis added) or, as Allsopp and Lepecki (2008, p. 4) described, "a means of inscribing bodily, social, and non-human movement in cultural, social, political and personal space." This expanded view of choreography as inscribing movement in dimensions and arenas other than the purely material connects choreographic approaches to considerations of the immaterial forces and influences acknowledged by actor–network theory.

The analysis of movement is well established in anthropology, science, and dance. Movement can be interpreted in the sociocultural frame of patterns of social and spatial interaction between people. The most well-known examples are Goffman's (1959) theory of social interaction based on a theatrical metaphor and Hall's (1968) proxemics. Movement has been conceptualized as nonverbal communication, most notably in Birdwhistell's (1970) kinesics, Kaeppler's (1978) kinemes and morphokines, and as meaning in patterned and structured movement systems such as sports games, religious rituals, and dance (Reed, 1998; Williams, 1991). Whereas these systems have tended to foreground the social and semantic dimensions of human behavior, interaction analysis (Jordan & Henderson, 1995) in HCI studies aimed to integrate both social and material aspects of human activity and interaction, with a particular focus on technology use. Actor–network theory differs from these approaches by its emphasis on the emergent and co-constructive characteristics of human–technology relationships and its symmetrical treatment of human and nonhuman actors.

Dance and movement notations focus on the changing patterns of motion in the body and between bodies in relation to parameters of space and time (Guest, 1984). Laban movement analysis has been used in dance and movement studies for observing both natural and choreographed movement and for exploring and choreographing movement. It continues to be used in fields traditionally associated with the physical body, such as dance studies (Guest, 1984; William & Farnell, 1990), physical therapy (Bartenieff & Lewis, 1980), and drama (Newlove, 1993), and also has been applied in anthropology (Farnell, 1999; Lewis, 1995). Since the late 1970s, Laban movement theory has been applied to various fields of computing, such as motion recognition, computer animation, and artificial intelligence (e.g., Badler & Smoliar, 1979; Camurri et al., 2000; Schiphorst, Lovell, & Jaffe 2002; Swaminathan et al., 2009). More recently, it has been applied in the design of interactive products and systems for its ability to capture the relations between movement, expression, and emotion (Fagerberg, Ståhl, & Höök, 2003; Jensen, 2007; Ross & Wensveen, 2010). It is becoming recognized as the primary crossdisciplinary shared language among researchers working at the junction of experiential and computational models of movement (e.g., Larboulette & Gibet, 2015; Lockyer, Bartram, Schiphorst, & Studd, 2015).

Several existing design frameworks provide ways of framing, conceptualizing, and interpreting movement (Bongers & Veer, 2007; Eriksson, Hansen, & Lykke-Olesen, 2007; Fogtmann, Fritsch, & Kortbek, 2008; Hornecker & Buur, 2006; Hummels, Overbeeke, &

Klooster, 2007; Klooster & Overbeeke, 2005; Ross & Wensveen, 2010; Schiphorst, 2007). Choreographically oriented design approaches include the choreography in interaction framework (Hummels et al., 2007; Klooster & Overbeeke, 2005) and the interaction quality framework (Ross & Wensveen, 2010), arising out of product design with an interest in the design of moveable products inspired by human movement. The kinesthetic interaction framework (Fogtmann et al., 2008) offered a range of concepts for thinking about movement in design (expressive meaning, kinesthetic empathy, movability, explicit/implicit motivation), which overlap with choreographic intentions. Several frameworks provide mapping strategies for interaction with technology and support of various kinds of movement-based activities (Benford et al., 2005; Loke & Robertson, 2013; Rogers & Muller, 2006; Wensveen, Djajadiningrat, & Overbeeke, 2004). Although these frameworks offer concepts for sensitizing the qualities of movement for interaction with technology and methods for generating and evaluating models, prototypes and solutions for movement-based interaction, less attention has been paid to how qualities of movement are inscribed—in varying strengths, in different technology design choices.

In the following sections, we briefly introduce the key concepts and terminology of actor–network theory and Laban movement analysis relevant to this paper. The actor–network concepts of inscription and translation are compared with established understandings in HCI of the concepts of affordances, constraints, and appropriation. We then present and explain our choreographic inscription analytic framework. The framework is illustrated through application to a selected case study of a gesture-based interactive technology, the eMoto affective gesture system (Fagerberg, Ståhl, & Höök, 2004). This case was selected as an example of an interactive technology that has not yet been widely adopted but presents an exploration of future likely possibilities of gesture-based interactions with mobile devices. The published work on the development of the eMoto system provides a solid foundation for our analytic purposes, especially because the authors of the eMoto system have utilized Laban effort and shape in combination with Russell's (1980) circumplex of emotion to derive their affective gestural plane model. A discussion is opened on a number of key insights, including how the relative strength of inscriptions may change according to different social settings and user appropriation over time, and how it is possible to translate inscriptions across different mediums by design to achieve desired programs of action. These insights are elaborated through hypothetical extensions of the eMoto system, positioned within a mapping of open- and closed-action spaces. We conclude by summarizing the key contributions of the paper.

ACTOR–NETWORK THEORY AS A RELATIONAL LENS

Actor–network theory (ANT) evolved out of the efforts of scholars of science and technology studies, notably those of Michel Callon, Bruno Latour, and John Law, in the 1980s. The etymology of the term is French: *acteur réseau*. Latour (1990) noted that the term *réseau* was first used by Diderot to describe matter and bodies without being confined to the Cartesian divide between matter and spirit. In their ethnographic study of practices in scientific laboratories, during which they analyzed the daily practices undertaken in a neuro-endocrinological laboratory in California, Latour and Woolgar (1979) demonstrated how scientific facts are socially constructed in a network of relations between people, inscription devices, and articles rather than being discovered.

According to Law (1999, p. 3), ANT may be understood either as a semiotics of materiality or as a material-semiotic approach: "It takes the semiotic insight, that of the relationality of entities, the notion that they are produced in relations, and applies this ruthlessly to all materials—and not simply to those that are linguistic." Therefore, relationality in ANT is not confined to explaining linguistic units but is extended by including any kind of human and nonhuman entity. The main area of interest for ANT researchers is the emergence and transformation of relations and patterns of relations. Analytically, humans and nonhumans are treated symmetrically, which allows researchers to understand the processes of becoming: becoming a kind of human, becoming a kind of nonhuman, and becoming a kind of collective of humans and nonhumans. Both humans and nonhumans can be authentic actors provided that they are capable of doing things and/or modifying "a state of affairs by making a difference" (Latour, 2005, p. 70–71).

Key Concepts of ANT

Mol (2010) argued that ANT may be seen simply as a list of terms. While stressing that there are many important terms in ANT, we limit the discussion to a few relevant terms only.

Actor, Actants, and Entities

According to ANT scholars, any entity that acts or makes a difference can be defined as an *actor*. Latour proposed the term *actant* in order to overcome the cultural anthropomorphic connotations of the term actor. Scholars of ANT have provided various definitions of the two terms. For example, an actor (or actant) can be "any element which bends space around itself, makes other elements dependent upon itself and translates their will into a language of its own" (Callon & Latour, 1981, p. 286). Latour (2005, p. 71) claimed that "any thing that does modify a state of affairs by making a difference is an actor—or, if it has not figuration yet, and actant." In general, anything can be considered as an actor/actant provided that it is able to make a difference and leave a trace.

Inscriptions and Translations

The power of inscription and translation, two important concepts of ANT, generates from their broad metaphorical scope and intertwined conceptualization. Metaphorically speaking, inscribing can be understood as an act of writing in or on anything. When an actor writes something, the written thing, that is, the inscription, influences the relations and roles of its actors to varying degrees. Any human or nonhuman actors, their effects, and their relations can be viewed as inscriptions for a situation. Inscriptions join in a collective of actors and influence the actors' capacities for action. Thus, a collective of human and nonhuman actors may be viewed as a collective of inscriptions that have the capacity to affect each other. In this respect, all interactions among the actors become processes of translation: Actors translate (read) the interests of other actors or their programs of action.

Akrich (1992) noted that the technical content of the objects embodies a script similar to a film script that defines the actors, their roles, and the settings. A script involves, in varying degrees of strength, programs of action that are translated into practice (Akrich, 1992; Callon, 1986). However, these inscribed programs of action may not succeed should the translation

processes vary; in addition, actual interactions between entities may unfold in unexpected ways. There is a mutual influence between interacting entities: Objects enable or constrain the actions of humans, but, at the same time, humans reshape the objects and their relationships with them.

The strength of an inscription may vary from very strong, that is, imposing one particular inflexible program of action, to very weak, offering many flexible programs of action. Latour (2005) provided an example of the progressively increasing strength of an inscription. The case cited is that of a hotel manager who wants his/her guests to deposit their room keys at the reception desk when departing the hotel. The manager first uses oral communication, then written notices to invite the desired behavior. However, neither form of communication implemented to define a desired program of action proves successful. Finally, a metal weight is attached to the room keys, an inscription that proves successful. While the first two inscriptions were weak, the final one was strong enough to impose the desired behavior on the hotel guests.

Translation has been used to explain various processes during the construction of a collective or network. Callon explained that translations are processes within which actors relate to one another and "the identity of actors, the possibility of interaction and the margins of manoeuvre are negotiated and delimited" (1986, p. 203). According to Murdoch, translation involves "the processes of negotiation, representation and displacement which establish relations between actors, entities and places" (1998, p. 362).

In effect, translations and inscriptions are intertwined processes. The objects of translation may include the inscriptions embodied in materials or the interests or intentions of some actors. In fact, the very act of inscribing something involves an act of translating. An actor translates its interests to different mediums, which can be anything from words and gestures to objects and laws and may be material or semiotic. These mediums embody the interests of the actor through the inscriptions, as in the case of the hotel keys. Therefore, inscriptions may be defined as embodied translations in a medium that will, in turn, be further translated by other actors in practice. This idea of translating inscriptions from one medium to another will be taken up in the Discussion section but from a design perspective.

CONSTRAINTS, AFFORDANCES, AND APPROPRIATION

In the related fields of HCI and interaction design, there are similar notions to inscriptions, such as constraints (Norman, 1998), affordances (Gaver, 1991; Norman, 1998), and appropriation (Anacleto & Fels, 2013; Dix, 2007). Norman (1998) explained that constraints can be viewed as limitations on the possible set of actions. Constraints can be defined by material properties of an object (physical constraints), social acceptability in situations (cultural constraints), a user's knowledge of situations (semantic constraints), or a user's reasoning of situations (logical constraints). The concept of affordance was originally developed by J. J. Gibson (1986) to explain how action possibilities emerge out of a relation between the material properties of a physical object and the capabilities of a living entity. For example, if an object has a large enough horizontal flat surface raised 50 cm from the ground, it may afford sit-on-ability for an adult person. However, the same object may afford climb-on-ability for a small child. Affordance is a powerful relational concept to understand how the space of possibilities is constructed by the properties and capabilities of an object and subject, respectively.

Although constraints and affordance are similar in terms of their role in shaping actions, there are some important differences between the two. While constraints are generally attributed to an entity or situation, affordances are attributed to the relationships between entities and emphasize the emergent and relational nature of possibilities for action. Constraints deal with the limitations of an entity or a situation on actions whereas affordances focus on both the enabling and constraining aspects of relationships on actions. The concept of appropriation, on the other hand, refers to the cases in which interpretation and usage of technologies deviate from their original purpose. Appropriation allows a less deterministic attitude to be developed towards the relationships among humans and other entities, in particular, technologies. Despite the fact that constraints, affordances, and appropriation are valuable concepts embracing, in varying degrees, the relational aspects in the possibilities for action, their focus is mainly upon unidirectional aspects from humans to technology in human–technology relations. In other words, their primary concern is either humans' interpretations of technology or humans' actions on technology, but is not about their mutual effects or entanglement.

The power of inscription and translation is attributable to their metaphorical scope and their intertwined conceptualization according to which an act of inscription is an act of translation as well. While the broad metaphorical scope facilitates application of the concepts to the relations between practically any entities, the intertwined conceptualization allows a balance between technological and social determinism. The notions of inscription and translation do not privilege any actors in their framing of possibilities for action. Humans and nonhumans are treated as symmetrical in analytic terms. It is possible to consider the notions of inscriptions and translations as an overarching pair of concepts unifying the concepts of constraints, affordances, and appropriation in the sense that they allow us to become aware of (a) the enabling or constraining aspects of relationships on actions (that is, affordances), (b) the constructed nature of affordances, (c) the actors taking part in the creation of affordances, and (d) the possibilities of deviations from affordances. Ultimately, employment of inscriptions and translations captures the mutual co-constructive nature of human–technology relationships and enables interaction designers to integrate a relational sensitivity into their design thinking at almost every decision-making step.

Latour (1992) explained how a simple case of closing doors involves complex translations and delegations between human and nonhuman actors. In his example, he compared a regular door, a door with a doorman, a door with a spring-based automatic door closer, and a door with a hydraulic door closer. One of his main points was that each alternative creates a very different inscription or program for action of opening, passing through, and closing the door. For instance, a door closer with a spring mechanism requires a very specific and quick way of passing through the doorway, otherwise it may slam in one's face. On the other hand, a door with a hydraulic closer retains the energy it receives from a person's movement and slowly releases it. Therefore, it does not require passers to be very quick in their movements. However, it does require more power to operate and may create an obstacle for children or older people with limited muscular power.

LABAN EFFORT AND SHAPE FOR DESCRIBING QUALITIES OF MOVEMENT

Laban movement analysis (LMA) and its companion Labanotation form a system and language for observing, describing, analyzing, and notating all forms of human movement. It was

originally developed by choreographer Rudolph Laban (1971) in the 1920s and was extended primarily by Knust (see Guest, 1984), Hutchinson (1977), Lamb and Watson (1979), and Bartenieff and Lewis (1980). It offers a framework and vocabulary for describing the structural and physical characteristics of the moving body, the use of space, and the dynamic, qualitative, and expressive aspects of movement through four major components: body, effort, shape, and space. We focus here primarily on the effort and shape components because they are intended for description of the qualities of movement, including the inner attitude of the mover. These two components of movement focus on "the changing patterns which occur in the ebb and flow of energy within the body" (Hutchinson, 1977, p. 12). For example, in dance choreography, this form of description conveys the aesthetic, emotional, and expressive qualities of the dance.

Effort

Effort (or the energy content) of a movement is described in the motion factors of weight, space, time, and flow, together with how a person indulges in or resists each factor. Each factor is represented by two polarities: Weight (light/strong), Space (direct/indirect), Time (sudden/sustained), and Flow (bound/free). Laban (1971) defined an effort element in terms of two components: the measurable, objective aspects of resistance, speed, direction, and control and the personal and classifiable aspects of levity, duration, expansion, and fluency. The first component relates to the properties of movement that can be measured by an outside observer. The second component relates to the movement sensation, that is, qualities of psychosomatic experience. Laban (1971, p. 81) described the significance of movement sensations as, "While in functional actions the movement sensation is an accompanying factor only, this becomes more prominent in expressive situations where psychosomatic experience is of utmost importance." For this paper, we restrict the analysis to the observational perspective, how movements are observed from an external point of reference to the body.

There are eight basic effort actions derived from the motion factors of weight, space, and time (flow is excluded). A diagram of the basic effort actions is illustrated as an effort cube (see Figure 1), otherwise known as the dynamosphere (Newlove, 1993). For example, a Float effort action is light in weight, indirect in space, and sustained in time. By changing the polarity in one factor, say from indirect to direct in space, the effort action becomes a Glide. The effort cube is a useful reference for quickly locating and identifying specific movement qualities in a field of movement potential, delineated by eight basic actions with names that refer to familiar actions in daily life.

Shape

Shape describes the spatial shaping of form—growing, shrinking, or carving patterns in space. It describes the expressiveness inherent in the form of a movement. Shape analysis was developed primarily by Lamb and Watson (1979). They described the shaping process in this way:

> The actual process of variation, which results in a succession of differently sculpted positions, can be described as a sculpturing, or shaping process. If we wish to become more aware of the shape of a person's posture pattern, as he [sic] dresses himself, or greets friends at a party, or elbows his way around a store, for example, it helps to imagine that all his joints are emitting vapour trails as though they contained jet engines. (Lamb & Watson, 1979, p. 49–50)
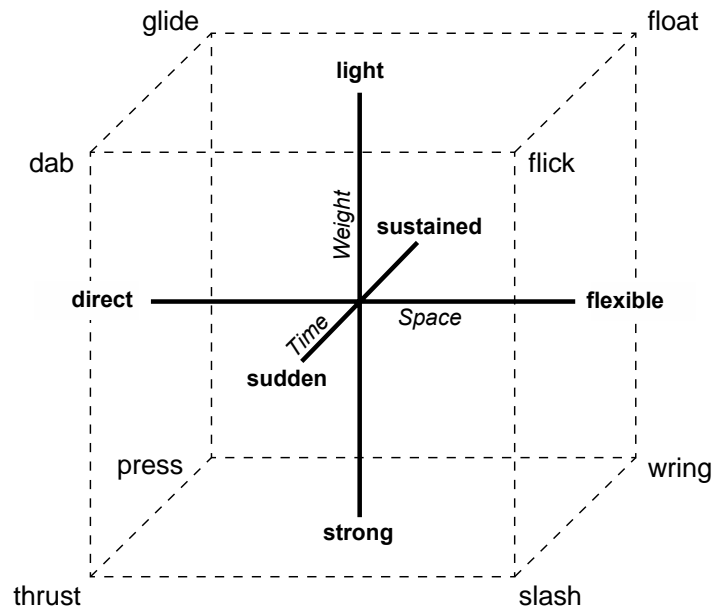
glide   float

light

dab   flick

Weight   **sustained**

direct   *Space*   **flexible**

Time

sudden

press   wring

strong

thrust   slash

Figure 1. The Laban effort cube maps the effort dimensions of weight, space, and time along axes into a three dimensional field delineated by eight effort actions on the vertices of the cube.

The spatial shaping of the body can be analyzed in terms of what forms the body makes and the relation of the body to itself and its environment. Shape analysis provides a set of descriptors for dynamic, fluctuating shape characteristics, classified into categories of Shape Form, Shape Flow, Shape Quality, and Directional Shape. Shape form describes the static shapes that the body takes, for example, pin-like, wall-like, ball-like, or screw-like. Laban (1971, p. 70) defined these four terms in relation to the organization of parts of the body as the (a) spine and its pin-like extension, (b) right/left symmetry of body and its wall-like surface, (c) limbs, together with their respective trunk regions curling and circling in ball-like shapes, and (d) shoulder-girdle and pelvis twisted against one another in screw-like fashion. Shape flow supports the body changing its form only in relationship to itself, for example, when breathing, daydreaming, or being self-involved (Bradley, 2009).

Shape quality describes the attitudinal process changing the shape of the body, for example, opening or closing or growing or shrinking, indicating the degree of extension or contraction in the body. More specific terms include rising and sinking (along the vertical axis of the body), spreading and enclosing (along the horizontal axis), and advancing and retreating (along the sagittal axis). Directional shape is when the body is directed towards some part of the environment, other person, or object. It can be spoke-like (e.g., shaking hands) or arc-like (e.g., painting a wall). The spatial intent of a movement determines the particular spatial shape that is produced as the movement unfolds. For example, the action of pulling a fishing net out of the water has a spatial intent that is directed along a radial line from the center of the body to the periphery where the hands hold the net. The related spatial shape of the body is one that expands and contracts along the path dictated by the spatial intent as the person repeatedly pulls the net towards the body (Bartenieff & Lewis, 1980). Together, effort and shape capture the dynamic process of human movement and provide a vocabulary for describing the salient features of the movement that can form part of a design language enabling communication and exploration of movement qualities.

THE CHOREOGRAPHIC INSCRIPTION ANALYTIC FRAMEWORK

In our bid to facilitate a movement-focused sensitivity to technology design, we bring together ANT's key concepts of inscriptions and translations and LMA's effort and shape descriptors into a single analytic framework focusing on choreographic inscriptions. While ANT's notions of inscriptions and translations allow us to bridge design decisions with movements enabled or disabled in practice, LMA provides us with an analytical model to understand movement in terms of various qualities of a choreographic nature. ANT typically works with an analytic unit of an action. Here we are interested in placing a movement lens on these actions, thus bringing to the fore the significance of the quality of inscribed movement patterns and potentials.

The framework consists of three dimensions: material, social, and choreographic inscriptions. For each inscription, the strength varies along a spectrum of weak to strong. The first dimension, material inscriptions, deals with the physical properties of an object or setting and the ways in which those properties act as strong or weak sources of influence on actors' potentials for action. It is possible to consider material inscriptions as constituents of affordances embodied by objects or the environment. The second dimension, social inscriptions, refers to immaterial forces such as social norms, informal codes of conduct, and formal rules and regulations regarding social behavior belonging to a particular social setting.

The third dimension, choreographic inscriptions, is a translation of the material and social inscriptions onto the movement possibilities of human bodies. It characterizes the actions in terms of movements using the qualitative vocabulary from Laban effort and shape. The dominant patterns of movement enabled or constrained by a particular interactive technology are identified. The character of the energy present in a movement gesture is described with the effort dimensions of weight, space, time, and flow, and/or summarized with an effort action (see effort cube, Figure 1). The relative strength, control, and timing of energy expenditure are captured in the effort analysis. For describing the ongoing dynamic shaping of the body in space and time, the descriptors of shape form, directional shaping, and shape quality are used, where appropriate. The choreographic inscription description is supplemented by visual illustrations of the spatial shaping of the human body. This visual aid helps to convey at a glance the range and type of spatial shaping generated by interaction with material artifacts in specific social settings.

It is important to point out that actual movement can never be reduced to a single LMA descriptor. The effort and shape descriptions are meant to be indicative only and attempt to capture the salient, observable properties of the movement in terms of expressive energy content and spatial shaping of the body. The abstract descriptions of effort and shape are translated in practice and may vary according to an individual person's state of embodiment at a particular point in time.

APPLYING THE FRAMEWORK: THE CASE STUDY OF eMOTO

In this section, we apply our analytic framework to a selected case study of a gesture-based interactive technology, the eMoto affective gesture system (Fagerberg et al., 2004). In brief, the eMoto system is an emotional text messaging service built on top of a Sony Ericsson P900 mobile terminal. Users can emotionally enhance their text messages by adding an

animated background that corresponds to the emotion they wish to communicate. The affective background is first created by the user interacting with a stylus (equipped with an accelerometer and pressure sensor) to record an affective gesture through shaking, swinging, and squeezing the stylus. After they have performed the affective gesture, they can then navigate through a circle of animated colors and shapes to select what they perceive to correspond visually to their emotional expression. This message is sent to someone who is then free to interpret the emotional content of the message.

The authors of the eMoto system have published several papers documenting the study of affective gestures (Fagerberg et al., 2003), the subsequent design (Fagerberg et al., 2004), and user evaluation (Sundström, Ståhl & Höök, 2005) of the eMoto system. We refer to these publications as resources for our analysis. We have reused two usage scenarios from the user evaluation study (Sundström et al., 2005)—the Perfect Job and the Racist Doorman—as a starting point for our analysis. Of the four scenarios in Sundström et al.'s (2005) user evaluation study, these two exhibited the greatest amount of body movement by participants; the other two resulted in very little body movement and are thus not particularly useful for demonstrating dynamic effort and shape qualities of movement. We re-present the results of their study in a new format here, an inscription analysis table, by extending the analysis to include more in-depth movement analysis in terms of Laban effort and shape descriptors and the

Table 1. Inscription Analysis Table for Usage Scenario: The Perfect Job.

Usage Scenario	The Perfect Job		
(from Sundström et al., 2005)	You write to tell your boyfriend that you got the job you applied for even though there were over a thousand applications.		
Emotional Expression	**Arousal (high/low)** **Valence (pleasure/displeasure)**	**Gesture**	**Setting (private/public)**
Excited	High & Pleasure	Wavy movement high in the air	Private: At home
Material Inscriptions	**eMoto system (weak inscription)**		
	The strength of the material inscriptions is intentionally weak, based on a desire for users to be able to perform affective gestures of their choice for specific emotions. However, the design of the input devices (stylus, mobile phone) will lead to some common movement responses, captured in the choreographic inscriptions. Holding the stylus requires a certain way of grasping it that will influence the expression of the total body gesture. The eMoto system offers shaking, swinging, and squeezing gestures through interaction with the stylus. The squeezing gesture is limited to the hands, whereas the shaking and swinging gestures can be enacted by the arm, with more or less involvement of the whole body. The accelerometer affords the user a waving action to express an excited emotion, together with gentle squeezing of the pressure sensor.		
	Physical environment (semiweak inscription)		
	When sitting at a desk (as was the case in the user evaluation study), the proximity of furniture and devices may constrain the expressive movement.		
Social Inscriptions	**Setting (weak inscription)**		
	When alone at home, there is likely to be less formality and inhibition compared to being in the company of people in the same environment.		
Choreographic Inscriptions	Effort	The effort graph corresponding to Excited is strong in weight, flexible in space, quick in time, and fluent in control of flow (see Fagerberg et al., 2003). This can also be classified as a slash-like effort action (see effort cube, Figure 1). This gesture tends to have a releasing in space quality.	
	Shape	For the example in the user evaluation study, the person is sitting at a desk and performing a hand-waving gesture above her head. The shape form is pin/ball-like shifting to wall/ball-like, the quality is spreading/enclosing, and the directional shaping is arc-like as the arms wave above the head. See visual illustrations of spatial shaping in Figure 2 (i) to (iii).	

implications of material and social inscriptions on the resulting actions. We have limited our analysis to the gestures performed and documented in the user evaluation study, although these are part of a broader range of interactions involved in the total message composition process. Inscription analysis tables for the two usage scenarios are given in Table 1 and Table 2.

The first five fields in the table (usage scenario, emotional expression, arousal/valence, gesture, setting) are taken from the user evaluation study (Sundström et al., 2005) and the affective gestural plane (Fagerberg et al., 2003). We have added the last three fields: material inscriptions, social inscriptions and choreographic inscriptions. Material inscriptions and social inscriptions contain descriptions of how these two types of inscription influence the resulting performance of affective gestures by the users of the technology. The relative strength of each inscription is estimated and discussed. The choreographic inscriptions field contains Laban effort and shape descriptions for the observed gestures from the user evaluation study. Illustrations of spatial shaping for each usage scenario are given in Figure 2 and Figure 3.

Table 2. Inscription Analysis Table for Usage Scenario: The Racist Doorman.

Usage Scenario (from Sundström et al., 2005)	The Racist Doorman You write to tell a friend that you and another friend could not get into the bar because of a racist doorman.		
Emotional Expression	**Arousal (high/low) Valence (pleasure/displeasure)**	**Gesture**	**Setting (private/public)**
Angry	High & Displeasure	Hard Shaking	Public: Outside, Near Bar
Material Inscriptions	**eMoto system (weak inscription)**		
	The strength of the material inscriptions is intentionally weak, based on a desire for users to be able to perform affective gestures of their choice for specific emotions. However the design of the input devices (stylus, mobile phone) will lead to some common movement responses, captured in the choreographic inscriptions. Holding the stylus requires a certain way of grasping it that will influence the expression of the total body gesture. The eMoto system offers shaking, swinging and squeezing gestures through interaction with the stylus. The squeezing gesture is limited to the hands, whereas the shaking and swinging gestures can be enacted by the arms, with more or less involvement of the whole body. The accelerometer affords the user to perform a shaking action to express an angry emotion, together with hard squeezing of the pressure sensor.		
	Physical environment (weak inscription)		
	The interaction takes place in an open space with little physical impediment to movement.		
Social Inscriptions	**Setting (semistrong inscription)**		
	The strength of the social inscription is defined by the tension between various social factors. Given the incident takes place in a public location and the user may wish to text immediately while in a vicinity near the bar, the affective gesture performed may be tempered by being in a public space. On the other hand, as he/she is in the company of a friend, this may support him/her in being more openly physically expressive than if in the presence of strangers. The presence of other people provides a strong influencing factor on physical conduct (Goffman, 1959).		
Choreographic Inscriptions	Effort	The effort graph corresponding to Angry is strong in weight, flexible in space, quick in time, and bound in control of flow (see Fagerberg et al., 2003). This can also be classified as a somewhat slash-like effort action (see effort cube, Figure 1). This gesture tends to be contained and tense.	
	Shape	The gesture observed in the user evaluation study was confined to an arm gesture, composed of a short, sharp, rhythmic up/down shaking action. The shape form is pin-like, and the directional shaping is somewhat spoke-like, with the active arm held in front of the torso. The variation in spatial shaping is low, with most of the movement occurring in the active hand and lower arm, as the user directs his/her emotion into squeezing and shaking the stylus. See visual illustrations of spatial shaping in Figure 3.	
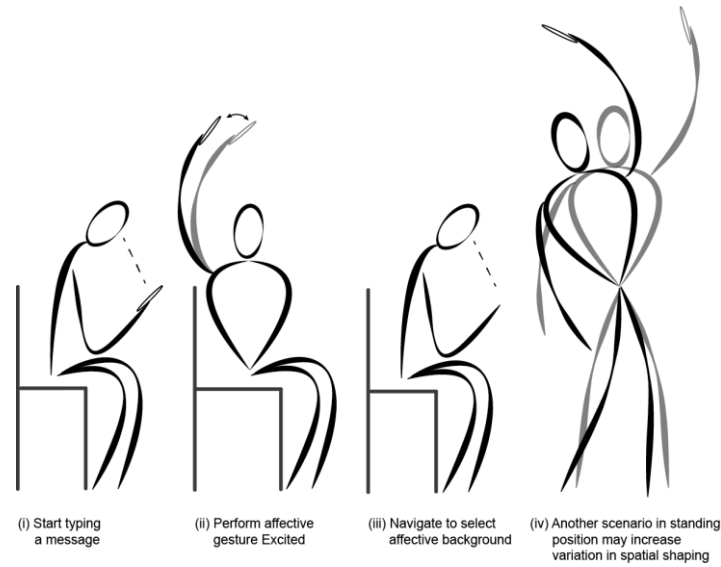
Figure 2. Spatial shaping for the excited emotion in the Perfect Job scenario: The dominant shaping patterns of the body are illustrated for the main interactions with the device while sitting in a private home setting, ranging from a fairly static posture in Steps i and iii to a more physically expressive movement of waving the arms above the head in Step ii. Step iv suggests how even more physically expressive movements may be obtained by standing instead of sitting.
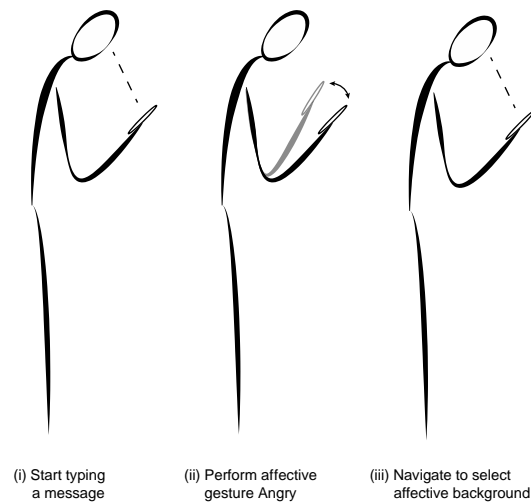
Figure 3. Spatial shaping for the angry emotion in the Racist Doorman scenario: The dominant shaping patterns of the body are illustrated for the main interactions with the device, which are limited in this case to a gestural shaking action of the arm while holding the device in a public space setting.

DISCUSSION

The choreographic inscription analytic framework enables thinking through how inscriptions evolve over time and are translated across different mediums, either by user appropriation or by design. By varying the strength of the material and social inscriptions, designers can explore how

this affects the qualities of movement considered socially acceptable and available for communication and expression. We illustrate our points through a hypothetical redesign of an eMoto application situated in different social settings across four action spaces with varying degrees of openness. First we discuss in general terms convergences and deviations of behavior in open and closed action spaces. Then we examine how inscriptions and translations can be transformed in strength through user appropriation or the creation of new technology-enabled social protocols— both instances where the designer has little control. Finally we explore how, through intentional design acts material, social and choreographic inscriptions can be deliberately transformed resulting in shifts across action spaces with different action possibilities.

Open and Closed Action Spaces

It is possible to see the human–technology relations on a continuum of openness and closeness enabled by weak and strong inscriptions, respectively. Weak inscriptions usually generate an open action space in which there are very few restrictions on the movements of humans whereas strong inscriptions facilitate a closed action space in which there are many movement constraints. Material and social inscriptions can be employed to generate a diagram involving four action spaces with varying degrees of openness (Figure 4). This diagram is useful for understanding how shifts among these spaces of possibilities may take place through evolving inscriptions and translations.

In the diagram, the dark gray space shows strong inscriptions on both social and material inscriptions, indicating strong restrictions on body movements. In contrast, the light gray zone indicates weak inscriptions on both dimensions, resulting in very little movement restrictions. The other two spaces can be considered semiopen spaces in which a combination of weak and strong inscriptions exists. Although a deterministic relationship between the strength of inscriptions and
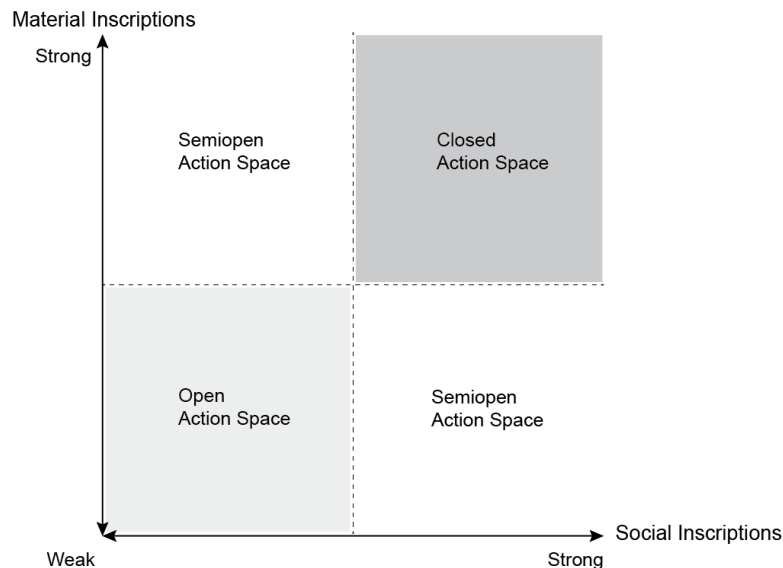

Figure 4. Mapping of action spaces to inscription strengths illustrating the range of open to closed action spaces relative to weak/strong inscriptions.

the observed movements can exist in many cases, there is a possibility that humans may perform unexpected movements. Our framework enables designers to deal with such nondeterministic situations. When one thinks about human–technology relations in terms of inscriptions, two kinds of nondeterministic instances are possible: convergences and deviations. These two instances are acts performed against weak and strong inscriptions respectively (see Figure 5).

In an open action space with few constraints, human movements usually start with very exploratory movements. In this discovery or getting-to-know phase, a movement vocabulary or some movement patterns are developed, and it is possible to see that the experience with these newly discovered movements start to act like inscriptions, shaping the future interactions in the same space. Therefore, the action space is no longer open as the movement experience in the space strengthens what were previously weak inscriptions. Convergence refers to those instances where human actors move from an open action space to a closed action space through the generation of self-defined inscriptions.

In an open action space with little or no guidance, information, or constraints on what movements to perform, there might be a tendency to stabilize or get to know such a chaotic or unknown system. In fact, the act of getting to know something is an act of generating a self-defined inscription. A series of workshops conducted by Kocaballi, Gemeinboeck, and Saunders (2010) demonstrated how convergence takes place in an open action space. In the workshops, pairs of participants engaged in game-like activities, each using a novel wearable device to communicate with the other in nonverbal ways. The participants negotiated less and performed the majority of their movements in the narrow range of possibilities right after they had constructed an interaction model. Kocaballi (2013) noted that the participants preferred not to engage in a continuous negotiation process, and there was a tendency to stabilize the patterns of action. His findings suggest that, in addition to providing an open movement space, an explicit interest in destabilization and divergence might be required in order to support more variety in actions. The tendency toward stabilization and convergence puts forward questions. How, through time, are movement patterns settled and become inscriptions for future movements? How do self-defined inscriptions transform into collectively defined inscriptions? And, how is convergence prevented in the cases where continuing free exploratory movements are desired?

On the other end of the spectrum, there is a closed action space with many constraints on human movements. In closed action spaces, human actors perform their movements in accord with strong inscriptions. However, there may be cases in which strong inscriptions are not strong enough for all human actors. Actors may translate the available inscriptions in different ways or deliberately prefer to translate them differently, even though the inscriptions are considered strong. In other words, actors may not interpret the available constraints, restrictions,

Open Action Spaces   Closed Action Spaces

⟵————————————————————————————————————⟶

Potential to converge to   Potential to deviate from
emergent inscriptions,   strong inscriptions,
norms, and habits   norms, and conventions

Figure 5. The spectrum of closed and open action spaces has potential for convergence to or deviation from varying types of inscriptions.

guides, or affordances in the intended ways or they may intentionally go against the scripted actions (Akrich, 1992). Deviations refer to those instances where human actors' actions deviate from the dominant scripted actions. It is important to note that deviations do not necessarily correspond to undesired instances. In the design literature, various approaches aim to utilize deviations as a way to empower users or the variety in their actions, such as designing for appropriation (Dix, 2007), designing for ambiguity (Gaver, Beaver, & Benford, 2003), staying open to interpretation (Sengers & Gaver, 2006), and seamful design (Chalmers & Galani, 2004).

Open and closed action spaces may help designers in understanding the enabling and constraining characteristics of human–technology relations on humans' movements. They can also be helpful in foreseeing deviations from the scripted movements or convergences to a limited set of movements. In general, although there may be deviations or convergences, open action spaces support more variety in movements while closed action spaces keep movements in a predictable range.

Transforming Inscriptions and Translations in Use

Having explained convergences and deviations in open and closed action spaces, we will now demonstrate how shifts across those spaces may take place by transforming eMoto's material and social inscriptions—through user appropriation or the creation of new technology-enabled social protocols. The current version of eMoto is deliberately designed to be open, flexible, and interpretative by its users so that they can develop the kinds of affective gestures most resonant with their individual preferences and personalities. The communication of emotional expression through the visual representations on the mobile device is also open to interpretation by the receiver of the message. Despite the designed-in or inscribed flexible interface, it may be the case that, over a period of extended use, a person develops a recognizable set of habitual affective gestures. That is, he/she tends to always perform the same kind of gesture for a specific emotion in a similar way. What was previously a weakly inscribed material influence on possible expressive movement behaviors has now become a strong bodily inscription. The person has incorporated a set of affective gestures into his/her bodily repertoire. The material inscription of the device has not actually changed—it was intended by the designers to be a weak inscription enabling flexible programs of action—but the practices of the human actor in appropriating the use of the device have translated the material inscriptions into a stable set of affective gestures, effectively becoming a strong choreographic inscription. In this case, a person's developing some habitual affective gestures over time changes the strength of inscriptions from weak to strong and transforms the action space from open to closed. As a result, a convergence to a limited set of gestures takes place.

In addition to developing habits, there can be other factors transforming the strength of inscriptions, such as continued exposure and the capacity of people to perceive inscriptions. Rico and Brewster (2010) maintained that humans' relationships with a device may create a new standard of social acceptability through continued exposure. Furthermore, the possession of a device may also allow a person to perform atypical gestures that are not normally socially acceptable in a particular setting because the person is perceived as a new hybrid actor, combining person and device. As the movement gestures are attributable to a person–device hybrid, the gestures may not be subject to the same social inscriptions[1] affecting a person without any devices. However, this would be the case only if the person believes that

his/her device is perceivable by observers. Rico and Brewster (2010, p. 894) observed that it is "not the energy required to perform a gesture that makes it acceptable, but the perceived appearance of that gesture." Therefore an important factor for social inscriptions is the public availability or perceptibility of gestures.

From the perspective of design, social inscriptions may represent a challenge because designers have very little control over the unfolding of these inscriptions that may cause deviations from the intended human and device interactions. However, participatory design methods—such as workshops, enactments, and prototypes—may prove useful for identifying and accommodating the unexpected effects of social inscriptions. Although material inscriptions are generated in accord with social inscriptions, in some cases the former might be employed to subvert the latter. For example, Serendipitor (Shepard, 2010), a mobile phone app for walking through city streets in a dérive[2]-like fashion, employs strong inscriptions, such as well-defined explicit and disruptive instructions about what to do at each step of interaction, in order to allow the app users to break up their daily habitual movement paths and patterns.

Shifting Across Action Spaces by Design

In this section, we discuss how transforming material, social, and choreographic inscriptions by design may result in shifts across action spaces with different action possibilities. We return to Latour's example of the hotel manager and room key to illustrate how an inscription's power to achieve a desired action is transferred from a weak social inscription in the first option (oral communication) to a weak material inscription in the second option (a written notice) to a stronger form of material inscription in the third option (a heavy weight attached to keys). While the first and second options, with their weak social and material inscriptions, stay in the open action space in which the hotel customers do not leave the keys at the front desk as requested, the third option shifts to the semiopen space in which a strong inscription of an attached metal made the majority of customers leave their keys at the reception desk. Figure 6 illustrates this transformation process.

In order to demonstrate how similar shifts may take place in eMoto, we introduce three cases involving one original and two hypothetical versions of eMoto. Case 1 involves the original eMoto The Perfect Job scenario (eMoto V1) in the home; Case 2 involves a hypothetical redesign of eMoto (eMoto V2) used at home; and Case 3 involves another hypothetical redesign of eMoto (eMoto V3) employed in a public place.[3] Figure 7 illustrates the three cases.

Case 1 with eMoto V1 involves a typical user interaction of communicating the emotion of excitement by performing vigorous shaking of the device with the arm held up above the head (refer to Table 1). In this scenario the person is sitting at a desk; the desk is a material constraint resulting in restricted physical movements of the body. An alternative option is for the person to perform the affective gesture while standing, which may result in more spatially expansive body movements. The spatial shaping of the body is depicted in Figure 2(iv). When standing, the action may become more pronounced as the hips swing to counterbalance the swing of the arms. The weak material and social inscriptions are translated by the human actor in flexible ways, as intended by the designers.

The eMoto V2 in Case 2 aims to encourage larger body movements through changing how the sensor data are computationally processed, achieved technically through programming the accelerometer to require bigger spatial gestures to generate data. For example, the emotional
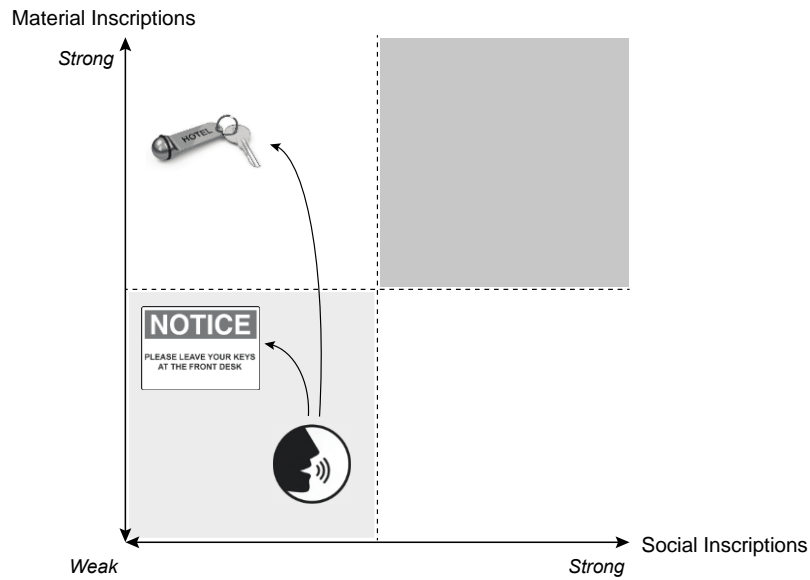
Material Inscriptions

Strong

Weak

Social Inscriptions

Strong

Figure 6. Transforming inscriptions for the case of the Hotel Manager: A weak material inscription of a written notice and a weak social inscription of an oral communication are transformed into a strong material inscription through the use of a heavy weight on the door key.
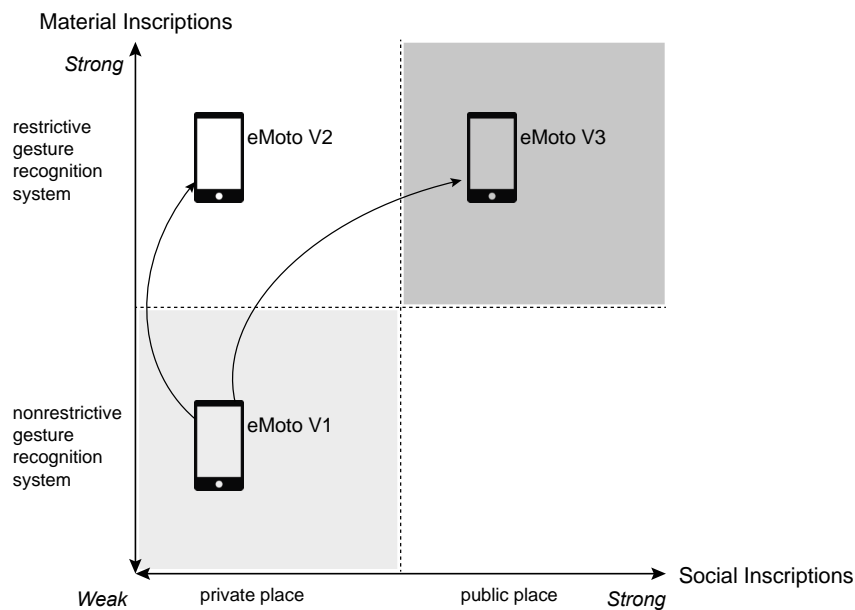
Material Inscriptions

Strong

restrictive gesture recognition system

eMoto V2

eMoto V3

nonrestrictive gesture recognition system

eMoto V1

Social Inscriptions

Weak   private place   public place   Strong

Figure 7. Transforming inscriptions for the three cases of eMoto: Version 1 has weak material and social inscriptions, transformed into a strong material inscription in Version 2, and strong material and social inscriptions in Version 3.

expression of excitement may require a more exuberant action, perhaps jumping up and down with the whole body with the arms also flapping up and down. In Laban terms, this action demands high effort, characterized crudely as elements of flick/slash for the arms/torso and

thrust/press for the legs. The shape component of the action can be described in terms of quality—whole body expanding/contracting in the vertical/horizontal planes—and directional—up/out into space as the body expands and down/in as the body contracts, with the spatial intent more outward oriented and with less attention on the device stylus. This is an example of how a desired choreographic inscription is then translated into the material properties of the device. The introduction of strong material inscriptions (i.e., the requirement of amplified gestures) can move Case 2 into a semiopen action space in which the system ignores smaller movements and requires users to perform more exuberant movements in a more limited range.

The eMoto V3 in Case 3 provides an additional functionality to formalize a set of affective gestures for sharing among friends. Often couples or good friends develop their own idiosyncratic social language—a set of gestures with specific meanings mutually created, recognized, and performed only within that group. The eMoto system could be customized to enable the creation of a formal gestural vocabulary for sharing between select people. This new feature would be a strong material and choreographic inscription of preferred or desired affective gestural expressions, changing the original weak material inscription embodied in the eMoto system to a stronger one. This social agreement may give the users a sense of permission to flaunt acceptable social behaviors, especially in public settings, enabling a potentially greater range of physically expressive affective gestures than usual. This is an example of how a social inscription embodied in the social agreement between friends is translated into a material inscription by adding new functionality to an existing system that is then translated into actual user actions corresponding to their shared gesture set. Through the introduction of strong social (i.e., public place and social agreement between friends) and material inscriptions (i.e., a user-defined gesture recognition system), Case 3 can shift to a closed action space in which the majority of the users' gestures can be performed in accord with the predefined set of gestures, in other words, a strong choreographic inscription.

In summary, the combination of open/closed action spaces and weak/strong inscriptions can help designers to think through the relative merits of enabling or constraining programs of action in material, social, and choreographic terms. It is possible through intentional design acts to inscribe desired choreographic or social behaviors in the material properties of technologies. However the actual translation of material, social, and choreographic inscriptions in practice can result in convergence or deviation from the expected programs of actions. Whether the transformation of inscriptions and translations takes place in actual use through acts of user appropriation or by intentional design acts, the application of our framework can draw attention to how the strength of inscriptions and translations evolves over time to produce varying qualities of movement in open or closed action spaces.

IMPLICATIONS FOR THEORY

Our framework employs some core concepts from ANT and Laban's effort and shape to help recognize multiple sources of influence on humans' actions and movements. The framework can be expanded to include various other material and social inscriptions according to the level of relational sensitivity desired. There are two main implications for design theory. First, humans' actions and movement choreographies cannot be considered independent phenomena; they take place within a network of other human and nonhuman actors acting as multiple

sources of influence, that is, inscriptions, on action possibilities. Second, the relations between inscriptions and actual actions and movements are semideterministic. Therefore, a strongly scripted choreography situated in a closed action space may not result in expected movements, whereas a choreography with weak scripts taking place in an open action space may not support sustained variety in movements. Although in practice it is not possible to consider an entire network of social and material inscriptions, developing sensitivity towards recognizing the multiplicity of inscriptions may prove useful for foreseeing possible cases of deviation from the desired flow of interaction and accommodating those deviations.

CONCLUSION

We have presented an analytic framework combining the notions of inscriptions and translations from ANT and a vocabulary for describing qualities of movement based on Laban effort and shape to draw attention to the range and quality of movement enabled or constrained by interaction with interactive technologies in social settings. The dimensions of material, social, and choreographic inscriptions characterize the framework. The power of the framework was demonstrated by applying it to the eMoto case study. This affective gesture system was selected to illustrate how different design or technology decisions can result in the inscription in bodies of different types and degrees of movement patterns and qualities, as well as the social factors influencing the performance of expressive movement behaviors.

The use of the ANT terms inscription and translation is critical for how we have defined the notion of choreographic inscriptions in this paper. They allow a balance between determinism and nondeterminism in the relations between humans and other entities and capture the ongoing processes of interpretation and appropriation involved in interactions between humans and interactive technologies. The actual movements performed in interaction can be thought of as a translation of both material and social inscriptions, resulting in a choreographic or movement inscription distributed across a network of people, artifacts, and protocols. The use of the Laban effort and shape descriptions of qualities of movement provides a language for partially articulating these choreographic inscriptions. Our aim is to provide designers with a language and vocabulary with which to reason about the qualities of movement in relation to technology design decisions and the social settings in which interaction with the technology takes place, not to prescribe or reduce the movements performed in actuality.

The framework contributes to the palette of tools available for sensitizing designers to the variety and qualities of movement that are enabled, constrained, or inhibited by technology design decisions. It is not limited to interactive technologies but can be applied more broadly to designed objects, structures, and systems. Furthermore, it is important to note that our framework does not suggest that designers should avoid constraining user behavior or should always support higher amounts of flexibility in technology use. Rather, our intention is to help designers to develop an account of enabling and constraining effects of design decisions, on the one hand, and the possibilities of deviations from the expected human–technology relations on the other. In future work, we wish to expand our analysis of the qualities of movement from the observational perspective taken in this paper to embrace the internal felt experience of movement. Rather than just designing for the outward form of movement, the notion of choreographic inscriptions can be extended to more fully consider

the design of kinesthetic choreographies. That is, it may be desirable to foreground the kinesthetic experience of movement within our framework, to better support this dimension in the design of interactive technologies. We believe that the analytic framework presented in this paper can contribute to the growing awareness of the significance of human movement within discourses and practices of technology design, and in turn, encourage the design of an ecology of artifacts that embraces and promotes a fuller spectrum of movement where the quality of movement is recognized as critical for the quality and vitality of life.

ENDNOTES

1. Latour's (1999) discussion of a case involving a gun and a man provides an invaluable insight on the agency of human and nonhuman hybrid collectives.

2. The word *dérive* is French for drift and refers to the situationist practice of exploring urban environments through "playful-constructive behavior and awareness of psychogeographical effects" (Debord 1956/2006, p. 1).

3. It is important to note that the cases illustrate a simplified consideration of social and material inscriptions in demonstrating how shifts may take place between different spaces of possibilities. In praxis, many other factors may be influential on the movements observed.

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Authors' Note

All correspondence should be addressed to
Lian Loke
Faculty of Architecture, Design and Planning
University of Sydney
148 City Road
Darlington NSW 2006
Australia
lian.loke@sydney.edu.au