

Hybrid Body Craft: Toward Culturally and Socially Inclusive Design for On-Skin Interfaces

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Sensor device miniaturization and breakthroughs in novel materials have enabled technology to progress directly onto the skin surface. However, unlike all other media, the human body is a complex and meaning-laden surface that encompasses a wearer's individual, social, and political identities. Yet, research in on-skin interfaces has focused on engineering aspects, with a scant focus on the cultural and social dimensions of device design. Hybrid Body Craft presents a design approach for bridging the cultural aspects of body crafts, which are existing cultural, historical, and fashion-driven practices and rituals associated with body decoration, with emerging on-skin interfaces. Here, we present a series of more socially and culturally inclusive on-skin interface designs that incorporate various emerging materials and technologies into body craft customs. A design space examines the impact of technology on increasing the agency of self-expression and communication, along with design implications for increased democratization and inclusiveness in design for body surface interfaces to enable the presentation of unique identities.

Since its inception nearly three decades ago from 2021, wearable computing has given rise to devices and gadgets on or close to the body. However, it was not from the early 2010s, with the rise of new material fabrication techniques and the miniaturization of sensor devices, that electronics could affix onto the skin or even be implanted beyond the realm of specialized medical applications.¹ The increased pervasiveness and proximity of these interfaces to the body renders them no longer as standalone gadgets but as a part of the wearer's identity. These *on-skin interfaces* come in forms such as smart tattoos and bandages, and expand the sensing capabilities of current mobile and wearable devices by facilitating direct access to the wearer's physiological signals. However, the majority of these on-skin interfaces have been developed with a focus on technical functionality and with a limited discourse on how they connect with greater cultural and

social contexts. This can result in a gap in the understanding with regard to wearer concerns about the social acceptance, device appearance, and potentially unwanted cultural and historical associations to on-skin interfaces,¹⁻³ which may deter their greater acceptance by the public.² On-skin interfaces need to address the complexities of culture and the formation of identities.

BACKGROUND AND DEFINITIONS

Wearable and Ubiquitous Computing

This article introduces the *Hybrid Body Craft* design approach and research practice, which aims to realize visions of Weiser's *invisible computing*⁴ and Abowd's *computation materials*⁵ on the skin surface through a culturally-sensitive lens. It builds on the work of Orth⁶ and Dunne,² pioneers in considering aesthetics, social perception, and human factors for wearable computers since their early stages. Yet this prior work is limited to clothing forms, which the *Hybrid Body Craft* approach expands for emerging on-skin interfaces. Vega's *Beauty Technology*⁷ incorporates technology in skin and its appendages, with a focus on the form of contemporary cosmetic products. *Hybrid Body Craft* builds on this influential work but expands to the full range of cultural body crafts and decorations,

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investigating technological hybridization not only in the final form but also in the crafting process.

Hybrid Craft in Human–Computer Interaction (HCI)

Hybrid Body Craft also builds on *Hybrid Craft* research in HCI, but adapts it for unique context of on-skin interfaces. Hybrid Craft⁸ investigates the integration of contemporary making practice with traditional craft, such as ceramics, basketry, book-binding, and mural painting. Craft-based inquiry⁹ has also been examined in HCI design research.

However, little prior work has centered on the *crafting* of technology on or in the skin surface. While traditional craft-based inquiry has focused on crafting for objects and also textiles,^{8,9} this work situates the habitual or ritualistic practices of altering the body surface through raw materials (e.g., applying makeup, and tattooing) also as a form of crafting. *Crafting for the body surface* introduces a whole new suite of challenges, from wearability issues, social and cultural perceptions, to the challenges of hybridizing an extreme slim form factor, which is underexplored by existing literature.

Defining Hybrid Body Craft

Body Craft

Deconstructing the term *Hybrid Body Craft*, *Body Craft* is defined as the existing cultural, historical, or fashion-driven practices for aesthetically decorating, ornamenting, or modifying the skin surface, especially focused on the direct permanent or nonpermanent editing of the skin surface instead of the adornment of clothing or accessories.

While *body art* and *body decoration*¹⁴ are other used terms in the anthropological literature, they fail to capture the ritualistic process of making, fabricating, *crafting*, and the *application* of these body arts, on the skin, which is central to this practice. The procurement and selection of suitable raw materials is also not captured under this term. Furthermore, they tend to not include more recent cosmetic and beauty practices such as makeup, nail art, or cosmetic surgery under this definition. *Body craft* is an inclusive term to bring all practices, procedures, and final output of editing the body surface under one umbrella.

Based on an extensive anthropological literature review, here I categorize body crafts into nine main categories, according to their proximity to the body, a categorization also adopted by other on-body technology work⁷ [gray boxes in Figure 2(a)]. Within each category, there are specific practices adopted by certain cultures, as well as some that are actively practiced in

contemporary times versus the past [white boxes in Figure 2(a)]. Due to the complexity of human practices, this categorization is not meant to be exhaustive or definitive, but instead intends to serve as a means to introduce the artifacts generated in relation to the space of body crafts. While there can be a discussion around the ethics, meaning, and sexuality behind some of these practices, it is outside the scope of this article as there are often culturally specific reasons for their adoption.

Hybrid Body Craft

It is a design approach and research practice that bridges cultural body crafts with emerging forms of miniaturized technology for expanding the agency of self-expression. It explores technological hybridization opportunities by deriving design primitives from the form factor, crafting and application process, material selection, to rituals of body crafts (see Figure 1).

Specifically, the approach explores technological hybridizations that have progressed directly onto (or *into*) the skin surface, but are not yet fully injected inside the body so they are no longer visible to human sight, and also do not replace entire body parts (as in Biomechatronics.) This is due to the fact that cultural body crafts are visible and often serve communicative functions,^{2,14} and thus, their hybridized forms also dominantly situate on the skin surface. In essence, *Hybrid Body Craft* examines the last frontier of technology that directly augments the skin surface, but does not yet infiltrate inside the body. By sitting on this last frontier of our body interface to the external world, I examine these technologies through a cultural lens to uncover their communicative qualities, and how they enable extended forms of identity expression previously not possible through their analog forms.

DESIGN CONSIDERATIONS

Following are three design considerations for this culturally grounded approach, which may also ease the adoption of on-skin interfaces into everyday lives.

Familiarity: Already Widely Adopted

Body crafts are already widely adopted with association to existing cultural customs. Examples include tattoos practices in tribal customs to signal rite of passage, and artificial eyelashes and makeup advertised by the multibillion dollar cosmetic industry and worn by countless people. Instead of introducing technology in new forms that may lack pre-existing cultural associations, this approach explores building technology on pre-existing *familiar* forms of body adornment. The importance of *familiarity* for social acceptance of

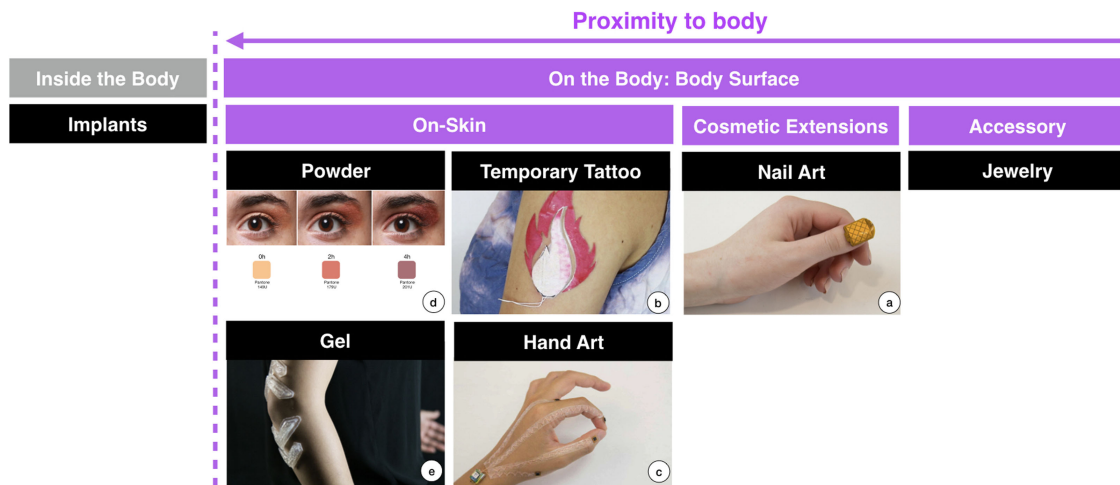


FIGURE 1. Example Hybrid Body Craft artifacts. (a) Hybrid nail art. (b) Hybrid temporary tattoo. (c) Hybrid hand art. (d) Hybrid powder. (e) Hybrid gels.

wearable devices has also been identified in HCI as a frequently applied design strategy.³

Embodying the Wearer's Identity: Potential to Overcome the Novelty Factor

Continuous, long-term user adaptation is a challenge faced by current wearable devices.¹⁰ Body crafts, for example, makeup and lotions, are often incorporated into the daily habitual practices of crafting one's appearance and identity. These habitual practices are highly malleable, and can evolve with the wearer to reflect their different identities. This embodiment of one's identity through wearable devices for increased adoption is also found in HCI and assistive technology literature.¹¹ By grounding the creation of on-skin interfaces in existing habitual practices, this approach explores on-body technologies that can become a meaningful part of the wearer's identity and incorporated into daily routines, not just another device to be discarded after the novelty factor wears off.

Customizability: Designed to Be Inclusive of Individual Preferences

Body crafts have the quality of being highly customizable and adaptable to various body locations and aesthetic preferences. This differs from the fixed form of current wearable devices. The importance of customization has also been highlighted for its role in managing the sociocultural issues toward wearable device acceptance.¹¹

Form Factors. Form factors in the wearable computing market are often predesignated, appearing in accessory-forms (e.g., smartwatch). Body crafts, conversely, come in primitive forms (e.g., pigments, and inks), and their end appearance can be crafted by the wearer to fit their needs.

Aesthetics. The wearable device market has partnered with fashion houses¹² to design and offer options to customize a device's appearance, namely a suite of cover designs for end-user selection. The importance of aesthetic customization has also been found to increase appeal to the wearer.^{2,11} This approach explores the customization of appearance beyond the selection of covers—instead, accounting for more low-level customization of one's identity and personal aesthetics. For low-level customization, I explore processes and materials crafted by the wearer to create desired on-body technologies of individual choice. I refer to this process as developing on-body technology as material rather than standalone device.

Function. Beyond form and appearance, the functionality of current wearable devices is also often fixed. This approach explores on-skin interfaces as easily accessible materials and processes that can be customized in terms of both appearance and functionality by the wearer.

DESIGN SPACE

Situated on the body surface, body crafts inherently possess *communicative qualities* as they are often visible to others.² Here, a design space [see Figure 2(b)] is presented to examine the communicative qualities

a Body Craft Categorization

Category of Body Craft
Specific Practices within Category (non-exhaustive)

Inside the Body	On the Body: Body Surface							On the Body: Accessories
Body Shaping	Piercing	Scarification	Body Painting	Tattoo	Scent	Nail	Hair	Jewelry
Lipombo	Lip Plates	Branding	Natural Pigment/Clay	Polynesian	Perfume	Natural Pigment	Hair Dying	Hair/Head
Foot Binding	Nose Plug	Cutting	Henna	Irezumi	Deodorant	Polish	Queue	Neck
Neck Elongation	Ear Plates	Chemical Scarification	Bindhi	Facial Tattoo		Sticker	Perm	Arms
Teeth Sharpening	Nose Piercing		Makeup	American Traditional		Extensions	Locks	Hands
Corsetry	Ear Piercing		FX Makeup	Neo-Traditional		UV Gels	Afro	Body
Orthodontics	Surface Piercing		Hand Art	Neo-Tribal			Extensions	Feet
Cosmetic Surgery	Dermal Piercing		Skin Gels					
			Temporary Tattoo					

b Changeability (x-axis) Reach (y-axis)

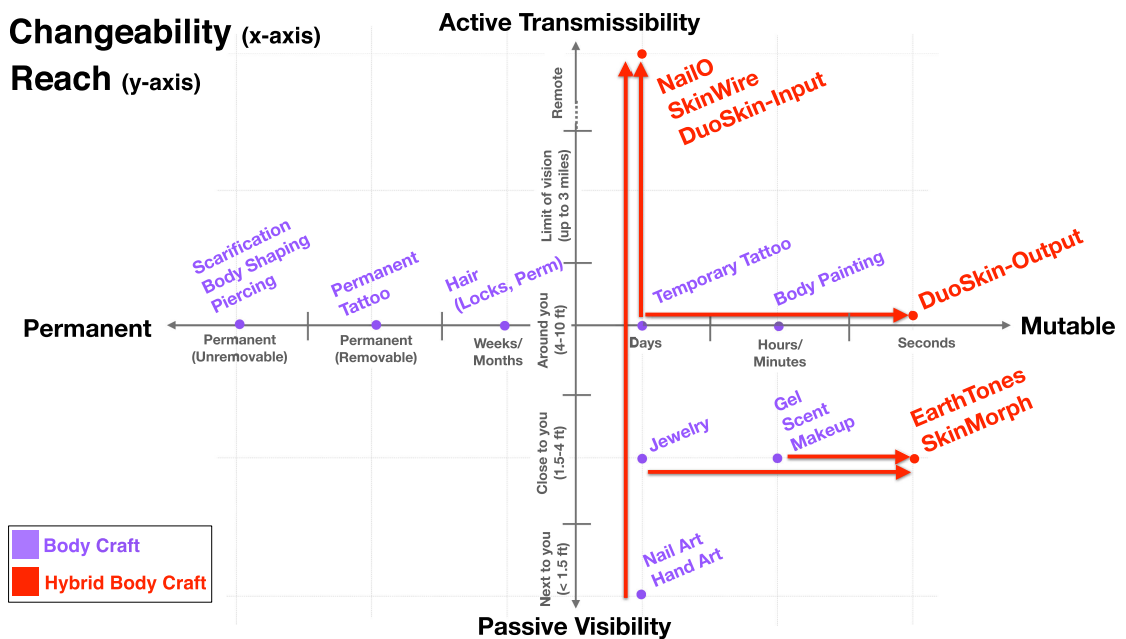


FIGURE 2. (a) Categorization of cultural body crafts into nine main categories, and situated according to their proximity to the body. (b) Resulting design space with changeability on the X-axis, and reach on the Y-axis. Purple indicates the relative positioning of analog body crafts. Red indicates shifts in the Design Space enabled through the incorporation of technology in Hybrid Body Crafts.

through the parameters of (1) *changeability* in presenting different sides of the self, and also (2) the communicative *reach* of each body craft.

Changeability

Changeability refers to the feasibility to alternate between different presentations of self. This design parameter builds upon Goffman's framework and

theatrical metaphor for social interaction,¹⁵ as well as the role of dress in the fashion theory literature for nonverbal (and often visual) communication.² Per Goffman,¹⁵ when we interact with others, there is a "front stage" in which we project a particular image of ourselves, and also a "backstage" where we no longer need to maintain a particular image and can "be ourselves." Body crafts and adornments are an indelible

part of this “personal front” presented to the world, as also elucidated by much fashion theory literature.² The flexibility to transition between not only “front” and “back” stages, but also between different “personal fronts” according to the social context makes visible different sides of one’s “self.” The design parameter of *changeability* examines a body craft’s flexibility to showcase these different sides of self.

In examining the rich space of body crafts, some are more *mutable* in material form than others. For example, body painting is a transitory form factor that can be subsequently removed and then reapplied. Permanent tattoos, on the other hand, are much less mutable. The X-axis of Figure 2(b) provides a relative placement of the changeability of the various body crafts.

Whether temporal or permanent, analog body crafts come in fixed states. On the other hand, technology can switch between multiple states with fast transition times. For example, an LED can transition between different states within nanoseconds. The incorporation of interactive technologies into analog body crafts offers an opportunity for increased mutability in the presentation of self. Through the example artifacts presented in the next section, I will demonstrate opportunities for increased mutability by incorporating technology.

Reach

Another design parameter I look at is communicative *reach*—i.e., when a person is wearing this body craft, what is the proximity with which they can communicate with others through this body craft?

This design parameter builds upon Edward Hall’s concept of proxemics¹⁶—the use of space as a form of nonverbal communication. Hall describes boundaries in which we mark our personal space as intimate, personal, social, or public. The intimate distance (0–1.5 ft) is what we reserve for our family and partners. Visually, we can see the other person’s closeup details or even be so close that the vision is distorted. The personal distance (1.5–4 ft) is the standard arm’s length in which we engage with friendships and acquaintances. The social distance (4–10 ft) is the most neutral and impersonal distance. We commonly engage with strangers at this distance. The public distance (10 ft to infinity) is used in public lecture halls and conference venues. While we can visually see another person’s entire body at a glance, detailed facial features are no longer visible.

We build upon these four distances to examine the communicative reach of various body crafts. Analog body crafts mostly communicate through their visibility to the other person, and thus, the coverage and

positioning of the body craft influences its reach. Specifically, this refers to the size of the body craft when worn on the body, and whether it is exposed or covered by clothing. For example, nail art, due to its limited surface area on the body, has relatively low visible reach—one would need to stand right next to the wearer to see it. However, in the case of tattoos or body painting that covers the entire body, one would be able to see it from much further away.

In the Y-axis of Figure 2(b), we can see a cutoff in communication through visibility when we reach the “limit of vision.” In a sense, in communicating through their visibility, analog body crafts are *passive* in their communicative abilities as they are subject to the viewer’s gaze.

While this is difficult to be done with analog body crafts (hence, the top section of the Y-axis in Figure 2(b) is empty of analog body crafts), remote transmission and interaction is an affordance of technology that can expand communication to remote distances. In a sense, when body crafts can wirelessly transmit information, the wearer is no longer subject to the passivity of others’ gaze but can now actively communicate what they desire beyond being there, which can also be viewed as a form of subtle interaction as examined in the HCI literature.¹³ For example, a woman wearing nail art that also functions as a wireless trackpad device in New York can input a message into her fingernail and transmit it to her family on the other side of the world. The following section will introduce example artifacts that expand reach to remote distance.

HYBRID BODY CRAFT ARTIFACTS

Following are the five examples of Hybrid Body Craft artifacts. Under each artifact is an analysis of how it extends the *changeability* or *reach* of the analog body crafts in a design space.

Hybrid Nail Art

NailO [see Figure 1(a)] hybridizes nail art stickers with flexible electronics, generating a fingernail-mounted gestural input surface. Using capacitive sensing on printed electrodes, this interface is capable of distinguishing among different finger-swiping gestures. Users can swipe the NailO to interact wirelessly with devices or connected environments.¹⁷

NailO achieves a shift in *reach* [see Figure 2(b)]. Nail art is a Body Craft that has low reach in terms of its communicative qualities due to its small surface area. An onlooker would need to be right next to the wearer to be able to see the nail art. However, now by adding wireless communication capabilities into a

finger nail trackpad, users can input something they wish to communicate on their nail art, and have it transmitted to someone in a remote location. The incorporation of technology shifts the communicative reach to the other end of the spectrum.

Hybrid Temporary Tattoo

DuoSkin [see Figure 1(b)] hybridizes temporary tattoos with slim and conductive materials, generating a fabrication approach for creating circuitry on the skin surface. The fabrication approach leverages gold leaf as the primary material, due to its characteristics of being skin-friendly, durable, and malleable in fabrication. Gold leaf allows for three types of interaction modalities in DuoSkin devices: 1) touch input sensing, 2) output displays, and 3) wireless communication with other devices.¹⁸

DuoSkin achieves a shift in both *reach* and *changeability* [see Figure 2(b)]. DuoSkin takes the form of the temporary tattoo form factor, which has a reasonable communicative reach depending on its surface coverage on the body. Now, with the input application (capacitive touch sensing capability), users can actively input something they wish to communicate and have it transmitted to someone remotely. With the output device (thermochromic skin display), there is an increase in *changeability* to switch between different presentations of self.

Hybrid Hand Art

SkinWire [see Figure 1(c)] hybridizes hand art—the placement of various materials on the hand for decoration—with hand-gesture interfaces. SkinWire introduces a fabrication approach of depositing conformal multistranded metal wires on a thin silicon substrate with a sewing-based technique, which enables patterning of complex wiring onto body locations with limited surface area. An example of shifting an index-finger and thumb-based inertial measurement unit (IMU) hand-gestural system, which typically comes in glove-based form factors, is demonstrated.¹⁹

SkinWire achieves a shift in *reach* [see Figure 2(b)]. SkinWire is inspired by body painting in the form of hand art. Similar to nail art has a relatively low reach due to its limited surface area. However, with the incorporated gestural sensing interface, one can now communicate, via gestural input, to someone remotely through their hand art.

Hybrid Cosmetic Powders

EarthTones [see Figure 1(d)] hybridizes cosmetic powders with chemical engineering, generating color-

changing powers that react to environmental hazards via color change. EarthTones presents analog display experiences through chemical reactions, thus overcoming the constraints of current wearable displays (e.g., rigid materials and limited battery life). The three cosmetic powders react to elevated levels of carbon monoxide (CO), ultraviolet rays (UV), and ozone (O3). Since the color changes are visible to the human eye, the powders maintain an aesthetic appeal.²⁰

EarthTones achieve a shift in *changeability* [see Figure 2(b)]. Makeup is one of the most temporal forms of body craft; the pigments start to decay from the skin throughout the course of the day, and it is meant to be removed at the end of the workday. However, now with interactive capabilities, the makeup form factor can alternative between multiple appearances within minutes.

Hybrid Gels

SkinMorph [see Figure 1(e)] hybridizes gels with thermally tunable properties, generating texture-tunable on-skin interfaces. SkinMorph uses thermally tunable hydrogels to create gel-like second skin layers with structural characteristics based on controlled external stimuli—that is, electronically controlled heating circuitry. Current on-skin interfaces focus on enabling electronic circuitry and display-like outputs, but they are limited in terms of exploring dynamically changing skin textures and degrees of stiffness. One goal is to create a novel class of body decorations at the intersection of tattoos and cosmetic body modifications—that is, a morphological second skin layer that alters an individual's skin structure while serving as expressive body art.²¹

SkinMorph achieve a shift in *changeability* [see Figure 2(b)]. SkinMorph takes advantage of the body painting form of FX makeup where one can sculpt new textures on the skin through the application of soft materials such as silicone. It also builds on the use of facial gels, often applied in the form of face masks, for replenishing nutrients into the skin. These are both temporal body crafts that are removed at the end of the day. In SkinMorph, such textural qualities are now programmable, and can alternate between soft and rigid at any desired instance. This further increases the mutability of the body craft form.

DESIGN IMPLICATIONS

Revisiting the Design Space

Shift in Changeability

There is a shift in *changeability* [X-axis in Figure 2(b)] for cultural body crafts hybridized as on-body *output*

devices. The incorporation of technology increases one's control to alternate between different presentations of self. The wearer can decide whether to (a) control their appearance themselves, (b) to give this control to another person, or (c) to be controlled by surrounding environments. When the appearance of a body craft is controlled by the wearer, one can shift between different presentations of self much more rapidly than before, gaining more control over one's projected "personal front."¹⁵ Alternatively, they could let *others* control their projected appearance. For example, if a person now allows his/her partner to control the makeup color on their face so it is always appealing to the partner. Is the projected self still representative of one's true identity? What does it mean, then, if one relinquishes this agency not to another human, but to our environments, or to the objects around us? This notion of displaying information from our surroundings is explored in the EarthTones project, with the various tensions underlined in the work by Kao *et al.*,²⁰ especially when the display is on the face. Have our bodies now become an even more mobile and interconnected display for information than our smartphones?

Shift in Reach

One can observe a shift in reach [Y-axis in Figure 2(b)] for cultural body crafts through the incorporation of technology. Cultural body crafts, due to their analog nature, are often limited to passive forms of communication through their visibility, as they are subject to being seen by others. There is, however, a limit to this passive communication. When one is no longer within others' limit of vision, the body craft ceases having the ability to communicate. However, for Hybrid Body Crafts, one can see that through the incorporation of wireless and interactive technology, one can engage in active communication beyond the limits of vision. This affordance of technology to communicate *beyond being there* is also a common trend in technological developments.¹³

Increase in Agency for Self-Expression

Reflecting on the shift in reach and changeability, one can observe how the hybridization of technology has increased the agency to change and communicate one's identity. This increase in agency also provides opportunities for more dynamic presentations of self for our modern times. Prior to the late 20th century, a person would be born with one identity, and be likely to carry this identity for the rest of their lives. However, due to globalization, mass mobility, and mass consumerism in contemporary times, it is now

common especially in the 21st century for a person to shift between multiple identities throughout their lifetime. Globalization and mass mobility have enabled a person to migrate between multiple cultures and transition between different geographic locations. Mass consumerism has encouraged the acquisition of goods in increased amounts, which in turn enables a person to easily wear and change between different styles of dress.

As examined by sociologist Zygmunt Bauman²² in the 1990s, we have moved away from a modernity that is "solid," "heavy," and hardware-based to a modernity that is "liquid," "light," and software-focused. In this liquid modernity, individuals live in constant flux, forming identities that are ever-shifting. Bauman notes that in a liquid modern life "there are no permanent bonds, and any that one takes up for a time must be tied loosely so that they can be untied again, as quickly and as effortlessly as possible, when circumstances change."²²

Philosopher Douglas Kellner²³ discusses major differences in forms of identity that has emerged in the 1960s versus those of the 1990s. In the 1960s, Kellner notes that albeit freely chosen, a "stable, substantial identity" was the common goal in the formulation of selfhood. In the 1990s, identity "becomes a freely chosen game, a theatrical presentation of the self, in which one is able to present oneself in a variety of roles, images, and activities, relatively unconcerned about the shifts, transformations, and dramatic changes."²³ In a sense, our identity has shifted from being *born* to being *made*.

Through the examination of the design space, one can observe how technology can contribute to this increased fluidity in self-presentation for our contemporary times. Technology enables self-defined forms of expression that have potential to overcome the pre-designated ways of presenting oneself. Technological affordances, including remote communication and radical speed, have moved analog body crafts from a "solid" to "liquid" state. Importantly, in this liquid state, the individual retains agency and control over how they wish to mold and shape their unique fluid identities.

New, Hybrid Aesthetics

Several Hybrid Body Craft artifacts sit between the boundaries of two types of body art. The incorporation of technology, while offering new functional capabilities, also presents opportunity to form new aesthetics.

The aesthetic of DuoSkin [see Figure 1(b)] sits between tattoos and jewelry. It is seen as jewelry mostly due to its metallic aesthetic. Yet, the close proximity to skin affords a new, interesting quality. It

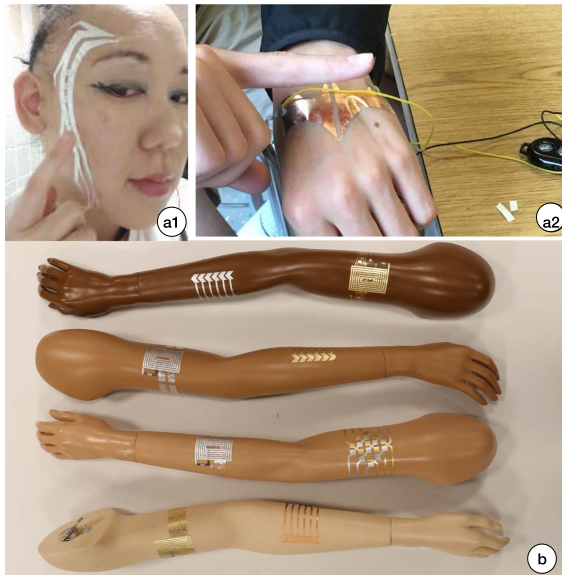


FIGURE 3. (a1) Examples of DuoSkin replications from Rei Cameron from the Arizona Science Center, who created a face tattoo for a museum event (image courtesy of Rei Cameron), and (a2) under the instruction of Shane Diller, students from The Steward School, an independent K-12 school in Richmond, Virginia, created an on-skin selfie button for taking photos. (image courtesy of Shane Diller) (b) DuoSkin device prototyping on different skintones.

has been called a skin jewel in some instances. DuoSkin devices can also often be paired with jewelry for unique, comparative aesthetics.

SkinMorph [see Figure 1(e)] is mainly inspired from the cultural form factor of gel facial masks and FX makeup, yet since it provides patterning on the skin, it can also be viewed as a form of (temporary) scarification body craft. Moreover, given it is an overlay on the skin, it can also be seen as a temporary tattoo. These multiple references result in the nuanced aesthetics of SkinMorph—it is seemingly familiar as there are cultural references from which it is drawn, but the use of new forms of technology (designing with hydrophilic gels) provides it with a foreign quality that is difficult to categorize into any predetermined bucket.

In summary, the new aesthetics of these Body Arts require increased forms of flexibility and experimentation in the design process, as one would be working with emerging form factors.

Democratizing On-Skin Interfaces

Body crafts have the quality of being bottom-up and incredibly accessible to the end-user. Each morning, a

person can engage in a habitual ritual of applying various body crafts on their skin, be this applying, hair styling, shaving, or applying cologne. I intend for on-skin interfaces to embody this personalized relationship with their daily habitual body craft practices. With this intent, many of the artifacts were created with fabrication processes that are user-friendly and readily accessible. As people can easily follow online tutorials for learning makeup, Hybrid Body Crafts are designed to reflect similar user-friendliness and accessibility. For example, the DuoSkin fabrication process was replicated by people we had never met to create their own interactive metallic temporary tattoos [see Figure 3(a1) and (a2)]. In a similar vein to how people learn to do their own makeup through online sources, these people either saw the DuoSkin project video or read the paper and then followed our fabrication process to replicate their own personalized devices. Exploring the development of on-body technology as *material processes* that are readily accessible provides opportunity for broadening participation to this possible future.

Designing for Inclusion

As Hybrid Body Crafts sit directly on the wearer's skin, it is important to consider device design for people with different skin tones. Similar to cosmetic products, it is important for these devices to encompass ethnicity in their design. Cosmetic makeup brands have often been criticized for the lack of consideration for the needs of women with darker (or exceptionally lighter) skin tones in their product lines. However, there has recently been an increase in cosmetic brands with a more inclusive outlook, often initiated by female founders who found it difficult to find makeup products for themselves. As on-body technologies move directly onto the body surface, there are interesting factors that mirror cosmetic products. In the initial prototyping process of creating DuoSkin, as we could only find mannequins of lighter skin tones, our prototypes were limited to explorations on one skin tone. To explore this issue, we later developed a process to customize mannequins into different skin tones [see Figure 3(b)]. During DuoSkin demo and exhibitions, we give examples of aesthetic customization across at least four different skin tones so it can reflect how the device would appear on wider populations. It is not the perfect solution to this complex issue, but I hope it serves as a starting point for conversation on inclusive design practices for on-skin interfaces.

CONCLUSIONS

Hybrid Body Craft is a design approach and research practice to hybridize technology with cultural body

craft materials, form factors, and application rituals. The intent of this approach is to integrate new technological functions, which have no prior relationships with the human body, with existing cultural practices. In providing an alternative lens for designing emerging on-body technologies, it seeks to move beyond an engineering-centric perspective to explore on-body design with greater connection to cultural and social contexts.

In the process of designing, engineering, and reflecting upon the developed artifacts, one can see how the integration of technology has expanded the agency for expressing oneself through body adornments. This increased sense of agency brings forth increased fluidity in presenting one's layered identities to the world. We can also see new forms of on-body aesthetics that have arisen through the integration of technology, as well as the need for increased democratization and inclusiveness in design for body surface technologies to enable the presentation of unique identity.

This article starts with grounding in cultural body crafts for designing emerging technology. It concludes by demonstrating how technology has, hand-in-hand, engendered new forms of expression previously not possible in analog body crafts. Technology and culture can be seen as two perspectives, which when taken together, can build each other up to progress toward new possibilities for the expression of self.

With an examination of the richness of cultural practices, Hybrid Body Craft seeks to create body surface technologies that celebrate the diversity of individual identities. In looking at fashion as a form of communication, the goal of this approach is to create technology that can be leveraged in ways to not restrain, but to open up opportunities to freely communicate who we are to the rest of the world.

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