Part 1: Purpose

1. Research Objective

We intend to explore the implications of new wearable technology. These artifacts utilize commercially available technology as found in small toys and household appliances. The wearable technologies are lightweight and closely approximate existing accessories and clothing; therefore minimizing potential risks and discomfort. The artifacts we intend to explore are a baseball cap, a beanie hat, a hooded sweatshirt, and a wearable pin. These prototypes will include an embedded e-ink display (as found in kindles, smartwatches, and other commercial products), a custom PCB (as found in small toys, remotes, and all electronics), and an embedded coil (as found in RFID keycards, car FOBs, and security stickers in stores). Electronic components will be properly enclosed and pose minimal risk to the user. The baseball cap and beanie hat will be worn on the head; the hooded sweatshirt will be worn on the torso; the wearable pin may be attached to a shirt, jacket, pants, backpack, or elsewhere, as the user sees fit. Because our technology has no included battery or power source, our technology poses lower risk to users than even very safe commercial electronics. All participation is voluntary; users are encouraged to wear and interact with the device as little or as often as they desire. Users are not required to wear the artifacts for any period of time. We hope to introduce users to our novel wearable technology and assess usability, applications, and general reaction.

The purpose of this research is to evaluate our battery-free dynamically-updatable wearable technology. In particular, we have embedded e-ink displays in two kinds of hats, a hooded sweatshirt and a wearable pin. These displays are low-power and only require energy when updating the display. They do not require power to maintain the display. Thus, we can power and update these displays using a mobile device and never need to charge, swap batteries, deal with power considerations, or otherwise maintain the electronics. The big picture goal is to explore a completely new paradigm of dynamic, computational wearable electronics that do not require as much intervention by the user. We expect users to see an increase in enjoyment, experience greater personal autonomy, and increased sense of self-expression as they use these dynamic wearables.  
  
The prototypes are very similar to unaugmented clothing and accessories with the exception of this dynamic portion. For each wearable prototype the e-ink display serves as a location where participants may change the appearance, visualize data, or otherwise personalize. The embedded coil is how power and data is transferred wirelessly from the phone to the embedded electronics. The custom PCB parses the data and updates the e-ink display. The e-ink display serves as a place for visual personalization. (We have included an image of one of our prototypes: hat-soccer-angle-close.jpg).

2. Research Hypothesis

We hypothesize that our new artifacts can afford unique interactions with existing technology and everyday objects alike. We plan to use the user study to gain useful feedback on form factor and potential interactions, as well as evaluate specific ideas, applications, and usability concerns.

Part 2: Background

Prior work has addressed the issue of power in wearable systems. Some new wearables resolve power constraints by leveraging chemical interactions rather than electrical ones [Kao 2017, Ohnesorge 2014]. Another way to address limited power resources is to lower power requirements. Prior work has leveraged the bi-stable, low-power nature of e-ink displays in battery-free devices that use photovoltaic energy [Grosse-Puppendahl 2016] or wire- less power [Dierk 2017, Dementyev 2013, Zhao 2015]. Our work contributes to this body of work by presenting a diverse array of wearable form factors that require no battery, yet have a persistent bistable display, and leverage the increasing ubiquity of wireless power.

Part 4: Qualifications of Study Personnel

Christine is a PhD Student in EECS and specializes in Human-Computer Interaction; she has run several user studies in this field and taken courses on user interface evaluation. Christine will be involved in experimental design, recruitment, collecting informed consent, data collection, analysis, and constructing the prototypes.

Molly is a PhD Student in EECS and specializes in Human-Computer Interaction; she has run several user studies in this field and taken courses on user interface evaluation. Molly will be involved in experimental design, recruitment, collecting informed consent, data collection, analysis, and constructing the prototypes.

Sarah is a PhD Student in EECS and specializes in Human-Computer Interaction; she has run several user studies in this field and taken courses on user interface evaluation. Sarah will be involved in experimental design, collecting informed consent, data collection, analysis, and constructing the prototypes.

Cesar is a PhD Student in EECS and specializes in Human-Computer Interaction; he has run several user studies in this field and taken courses on user interface evaluation. Cesar will be involved in experimental design, collecting informed consent, data collection, and analysis.

Rundong is a PhD Student in EECS and specializes in Human-Computer Interaction; he has run several user studies in this field and taken courses on user interface evaluation. Rounding will be involved in constructing the prototypes.

Christine, Molly, Cesar, or Sarah will be conducting the user study.

Eric is the Principal investigator and a Associate Professor of Computer Science; he will be overseeing the study, advising on research design, and general oversight. He also specializes in Human-Computer Interaction as has conducted several user studies in this field.

Part 5: Subject Population

Participants must be at least 18 years old. We hope to have a distributed range of ages between 18-65 years old. We hope to have roughly equal proportions of males and females. We hope to have diverse races and ethnicities. All participants will speak English fluently and be literate.

We hope to have a maximum of 60 participants in our user study. For this sample size, we plan to recruit 120 subjects. Having 60 participants will allow us to have some diversity amongst our participants and be able to account for individual differences when evaluating our wearable devices.

Part 6: Recruitment

Participants will be recruited from the Berkeley area using campus mailing lists and Craigslist ads. We will send out a general call for participation by asking a neutral third party (the list administrator of campus mailing lists such as Computer Science and Design) to forward an email. The only role of the list administrator is to forward this email. Interested persons may then initiate contact with the researchers, who will collect informed consent at the time of the user study.

Part 7: Screening

We will be looking for an equal distribution across age ranges, as well as an equal distribution of gender. Participants must be at least 18 years of age, speak English, and be literate. We will screen users based on prior experience with wearable technologies, aiming for a range of experience levels, and which devices they currently own.

Part 8: Compensation

a.

1. For any in-lab experience, participants will be compensated at the rate of $20/hr. For any phone interviews, participants will be compensated at the same rate.

2. For the longitudinal portion, participants will be compensated at the rate of $5/week, similar to how Kim et al. did (for a maximum of $10), and an additional $5 for every set of 10 photographs (maximum of $20).

The initial interview will last approx. 30 minutes; the final interview will last approx. an hour. Participants will be compensated a maximum of $60 for their participation.

Compensation will be in the form of an Amazon gift card. The gift card will be emailed to an email address that they provide. If a subject withdraws before the study is complete, their compensation will be prorated ($20/hr for interviews, $5/week for completed participation, $5/set of 10 photos) and they will receive an Amazon gift card in the prorated amount. Only the participant’s email address will be collected for payment purposes.

b.

Compensation:

1. The average wage for design from the oDesk design platform is $15, so our rate of $20 is fair.

2. We follow best practices of Kim et al. for their longitudinal studies.

Thus, best practices have established that these rates are reasonable while avoiding undue influence on the participants.

Previous work in our lab also compensated at $20/hour (Protocol ID: 2014-11-6920 and protocol 2017-06-10084)

Part 9: Study Procedures

1. After we have thoroughly explained and received informed consent, we will interview participants in a UC Berkeley campus location to gauge their interest in and knowledge of wearable/mobile technology. We will ask about their use of wearable/mobile technologies and familiarity with them.

Next, we will demonstrate our new wearable technology. Each participant will be introduced to our three prototypes: baseball cap/beanie hat, hooded sweatshirt, and wearable pin. We will explain the technology and allow them to examine the prototypes. We will demonstrate some simple interactions with our prototypes. We will give participants the opportunity to wear or interact with these new devices and use them. The wearable technologies are lightweight and closely approximate existing accessories and clothing. Electronic devices are properly enclosed and pose minimal risk to the user. As mentioned previously, the electronic components are commercially available and commonly found in toys and household appliances.

Following the demonstration, participants are encouraged to choose one of the three prototypes to take out of the lab for 2 weeks, during which they will be free to interact with the wearable as much or as little as they choose. The goal is to explore how users experience the wearable device in their natural day-to-day lives. We will also give users an accompanying mobile application. We will instruct them to download the application onto their personal phone. The accompanying mobile app will also collect logs based on usage. Specifically, the application will log data only when the user interacts with their wearable device. It will log the date, time, and image/text that was uploaded to the display. This data logging is the same for each of our three prototypes. These logs will be stored locally on the mobile device, and transferred to us during the final interview. If we publish any information from these logs, it will be only published in aggregate, with any identifiable or personal information removed and anonymized. The main purpose of this is to inform our interviews, to elicit specific questions about usage.

Usage description: The user will choose a design on their phone to be uploaded to the display. They hold the mobile phone up to the embedded coil for approximately 2.5 seconds in order to power and send data to the device. The display will now showcase the new design. After removing the phone, the device will be unpowered yet the display will continue to showcase the design. We expect users will update their displays between multiple times a day and only a couple of times over the entire study period. We are interested in how, why, and when users interact with these devices. We will not explicitly instruct participants to interact with the wearables in any way.   
  
To inform our final interview, and to prompt participants' memories, the logs will capture the date, time, and image/text that was uploaded to the display. Dynamic textiles and fabric are on the horizon, and our work probes understandings, contexts, and reactions to this cutting edge technology. Ultimately we hope to create design guidelines to inform the future design of such dynamic wearables.

During the "out of lab" study time period, we may ask participants to take pictures with their smartphones, capturing their thoughts. We'll encourage participants to capture contextual information capturing how and where they are interacting with the technology (for instance they may take a picture of their hat sitting on their desk, or their hooded sweatshirt draped over the back of a chair). The pictures will be emailed directly to investigators using Berkeley email addresses only, all password protected, and will only be accessible to investigators. The main purpose of these images is to inform our interviews, and to prompt reflection by the participants.

Finally, we will interview participants once more to gauge reactions and to see if any of their initial opinions (from the entry interview) have changed. We'll discuss how they used the artifacts, review materials such as the photographs and collected logs, and capture how participants experienced the artifacts in their daily lives. In the rare case that a participant is unavailable, we may conduct this interview over the phone. At the final interview, we will request participant permission to publish photos from their "out of lab" exploration. These photos will be anonymized where possible, and participants will have the option to exclude any number of photos.

Part 13

i)

All recruitment information will be collected using a key-value system. A single physical document (key) will link the research data to identifiable information.

Recorded logs will be stored locally on the user's phone and transferred to us during the final interview. These will be stored with the unique ID in the key-value system described above, and not identifiable. They will be stored in a password-protected, two-factor authenticated Google Drive folder accessible only to investigators.

The screening survey responses will be stored in a password-protected, two-factor authenticated Google Drive folder accessible only to investigators.

Research records, including audio recordings and recorded logs, will be stored in a locked cabinet (physical materials), in a secured building and/or on an encrypted, and password-protected computer (digital materials).

Ii)

Personal identifiers (email addresses, key) will be destroyed a month after the end of this study. Main research study data (logs, photographs, interview transcriptions, screening survey responses) will be retained no longer than five years after the conclusion of the study.

iii)

Audio data will be transcribed no later than one month after the conclusion of the study and deleted after transcription. Transcriptions will be retained for no longer than five years.