ADVANCING HAPTIC DESIGN

Focusing on Human Interpretations of Tactile Effects

immersion®

STORYTELLING WITH TOUCH

How can we use the sense of touch to tell a story?

Storytelling is at the heart of everything we do as humans. It's how we interpret and communicate with the world around us. In business, knowing how to tell a story effectively – whether it is for entertainment or advertising, in a game, to sell a new product, or engage with emerging technologies such as VR and AR – is an often overlooked yet critical skill.

Touch is a powerful medium in storytelling; there are specific things that touch does that are different from the other senses. Haptics, the technology of touch, is a unique way to sharpen and amplify a message.

Storytellers need to understand the value that haptics can bring to shape a story and maximize the impact on their audience, both emotionally and physically.

Simply put, adding the sense of touch to your story makes it more memorable - and more effective.

THE WORLD IS TACTILE

Haptics can revolutionize human-computer interfaces and change how we see and feel technology.

As we move through the world, we experience our physical surroundings through our sense of touch. It's more than just what we sense with our fingertips. We map out our physical reality as our body moves through space. We use our sense of touch to learn about the world through body movement and active exploration.

Touch also creates belief in external reality. Think of the old phrase, "Pinch me, I'm dreaming." Our minds are better at believing something when we can physically feel it. New technologies like VR use touch to convince users to believe in the experience.

The sense of touch does something else extraordinary – it enables an extension of our body through extended proprioception. Proprioception refers to the sense of our own body – our posture, the angles of our joints, and so on. It's how we know the position our body is in even when we close our eyes.

For example, a blind person who uses a cane to move around doesn't just feel a cane; he feels the ground through the cane. The person's brain-body map incorporates the cane as a part of his body and extends the physical sense of touch to the cane.

Touch also facilitates affective interactions – emotional, intimate, interpersonal touch. Think of a warm hug, a firm handshake, or a high five. Touch is also an essential part of non-verbal social cues. According to published scientific studies, touch and emotional engagement promote healthy psychological and physical development in babies. Lack of touch is considered detrimental to childhood development.

Natural human communication requires touch, and because of this, digital devices are vastly better when they can respond with touch cues.

Devices without touch feedback are not capable of enabling natural human communications. Haptic technology has the potential to revolutionize human-computer interfaces, making them more natural, emotional, and familiar, more like our non-digital lives.

TOUCH...

lets you understand through active exploration

lets you learn about the world through movement

creates belief in external reality

enables extended proprioception

facilitates affective interactions

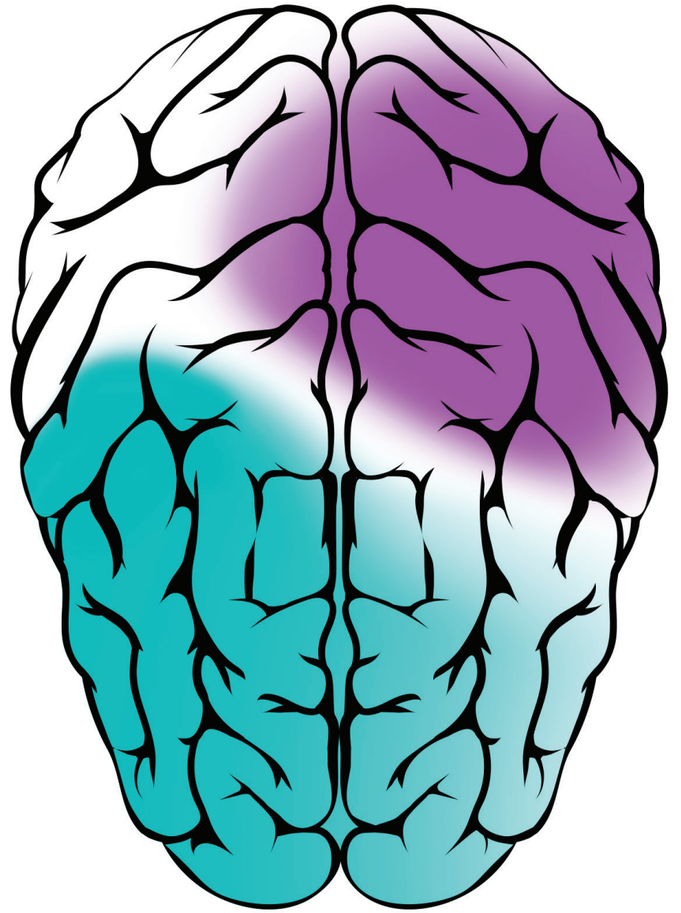
HOW OUR BRAIN RESPONDS TO HAPTICS

Touch is understood in the deepest, oldest parts of the brain.

To understand why haptics are so powerful, we should start with how the brain reacts to touch. Although the brain takes up only 2% of our body weight, it consumes 20% of total energy and oxygen. Made up of 86 billion cells, the brain is responsible for an average of 50,000 thoughts per day. In this emotional powerhouse, touch reaches the most primal parts of the brain – those associated with spatial awareness, emotion, and instinct.

When haptic-enhanced virtual objects are felt, they seem real because they activate nerves in the muscles and skin. This sends a message to the brain allowing us to create a spatial map of our environment. The brain then combines these signals with visual and auditory input to create a holistic experience.

This advanced processing occurs in less than a fraction of a second and has great consequences in how experiences are perceived. Used at the right time, haptic activation instills a memorable feeling about the experience. Multiple micro-moments like these, added together, make the difference between a passing event and an unforgettable experience.



The asymmetric engagement of the frontal lobes is where value-based decision making takes place. The right frontal lobe activation is related to dislike or avoidance reactions, while the left frontal lobe is associated with appeal or approach reactions. We measured the amount of activity in these two parts to understand the impact of haptics participants in the study.

USING NEUROSCIENCE

Strong haptic responses are associated with increased preference and memorability.

To learn more about effective haptic design, Immersion partnered with True Impact, a neuroscience research firm, to conduct an experiment on users' neural responses to digital touch. The goal was to measure the differences in perception through/or based on different haptic design experiences.

In the experiment, we learned that the brain reacts strongly to haptics, shown in intensified emotional responses from the subjects. The research also revealed that study participants preferred experiences with strong haptics and that these experiences were more memorable. In addition, we learned that the design intent and context behind haptic feedback makes a difference, no matter the goal or message.

Ontario, Canada-based True Impact is a research and consulting firm whose mission is to drive brand growth with insights from neuroscience and psychology. True Impact has transformed processes and empowered marketers with research on non-conscious mechanisms of decision making through neural and bio-metric influences, analysis of user behavior from multiple sources and recommendations that drive bottom-line results. Learn more about True Impact at www.trueimpact.ca.

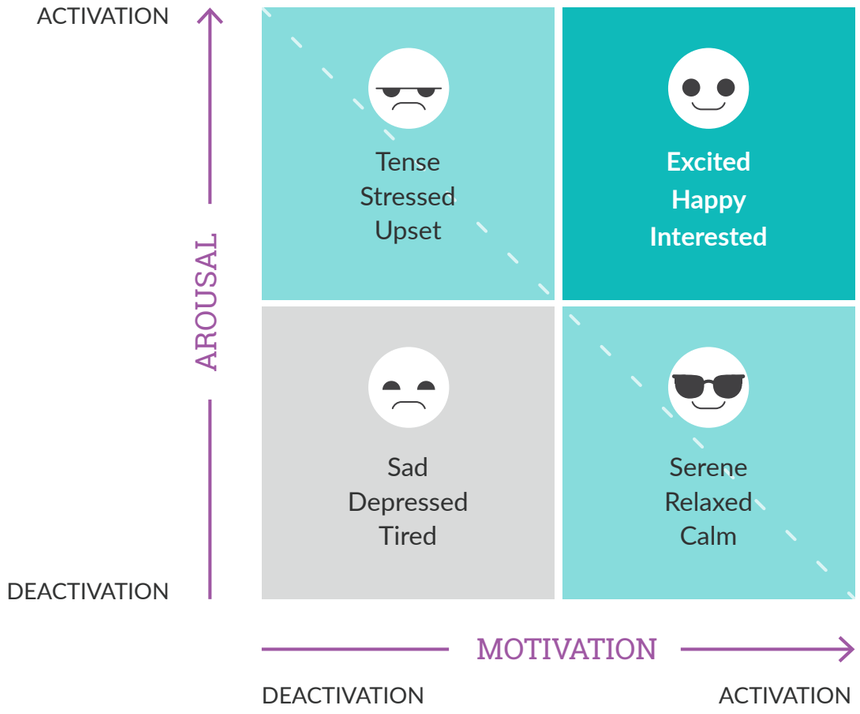
EEG SPECIFICATIONS & NEURAL MEASURES

We used academic-grade, full-head brain imaging technology called electroencephalography, or EEG, to measure brain waves with split-second precision and collected data on each test subject's motivation, arousal, cognitive load, and heart rate.

MEASURING RESULTS

The results from the study with True Impact were interpreted using the valence matrix, a standard tool to measure appeal and desirability. In this method, the data captured on motivation and arousal were averaged and separated into four quadrants based on the level of activation in the corresponding regions of the brain. We combined the results of this data with readings on heart rate and levels of cognitive load to produce meaningful analysis from the study.

Too much or too little cognitive load indicates that the experience is mentally stressful or disengaging. Whereas, a high level of activation for both motivation and arousal combined with an optimal level of cognitive load suggests high engagement, consideration, and understanding. Subjects in this state of mind are recording memories and are receptive to ideas and messages, which can create opportunities to influence desirability.



Verbal feedback on haptics from participants of the study:

"Haptic feedback makes it easier to remember the video; it's a good way to market products — more memorable."

"The video came to life with haptic feedback; I felt part of it."

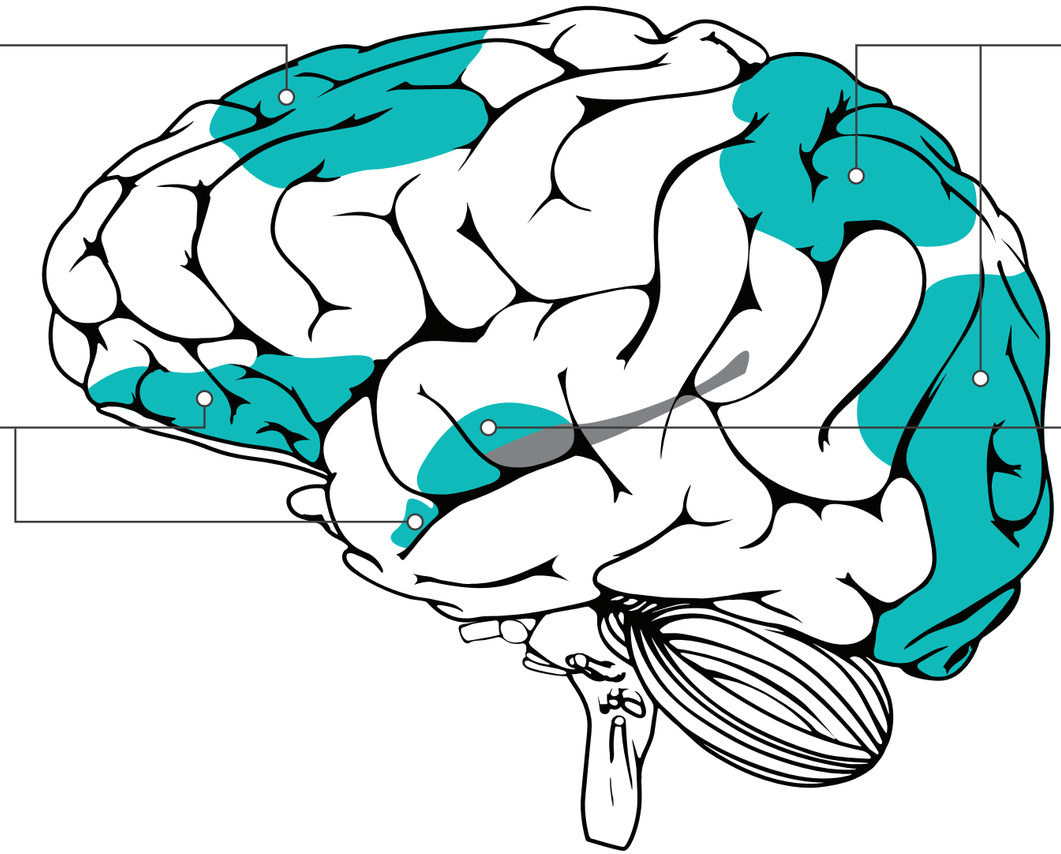
WHAT DID WE MEASURE IN THE STUDY?

COGNITIVE LOAD

Measured in the dorsolateral prefrontal cortex, cognitive load represents mental effort exerted to understand or process subject matter. “Is the stimulus intuitive or difficult to understand?”

MOTIVATION

Measured in the orbitofrontal cortex and ventral striatum, motivation represents the propensity to approach or avoid subject matter. “Is the stimulus interesting or repelling?”



VISUAL ATTENTION

Measured in the parietal and occipital cortex, visual attention represents spatial attention and the region of the visual field where attention is focused. “Is the stimulus in or out of the spotlight of attention?”

AROUSAL

Measured in the amygdala and confirmed by heart rate, arousal represents the degree of emotional intensity evoked by subject matter. “Is the stimulus exciting or calming?”

MAIN STUDY OBSERVATIONS

Haptics affect recognition, awareness, and perceived quality of experience.

Overall the results of the Immersion/ True Impact study show that haptics add 11% to brand or product recognition and awareness, and increase the perceived quality of experience by 18%.

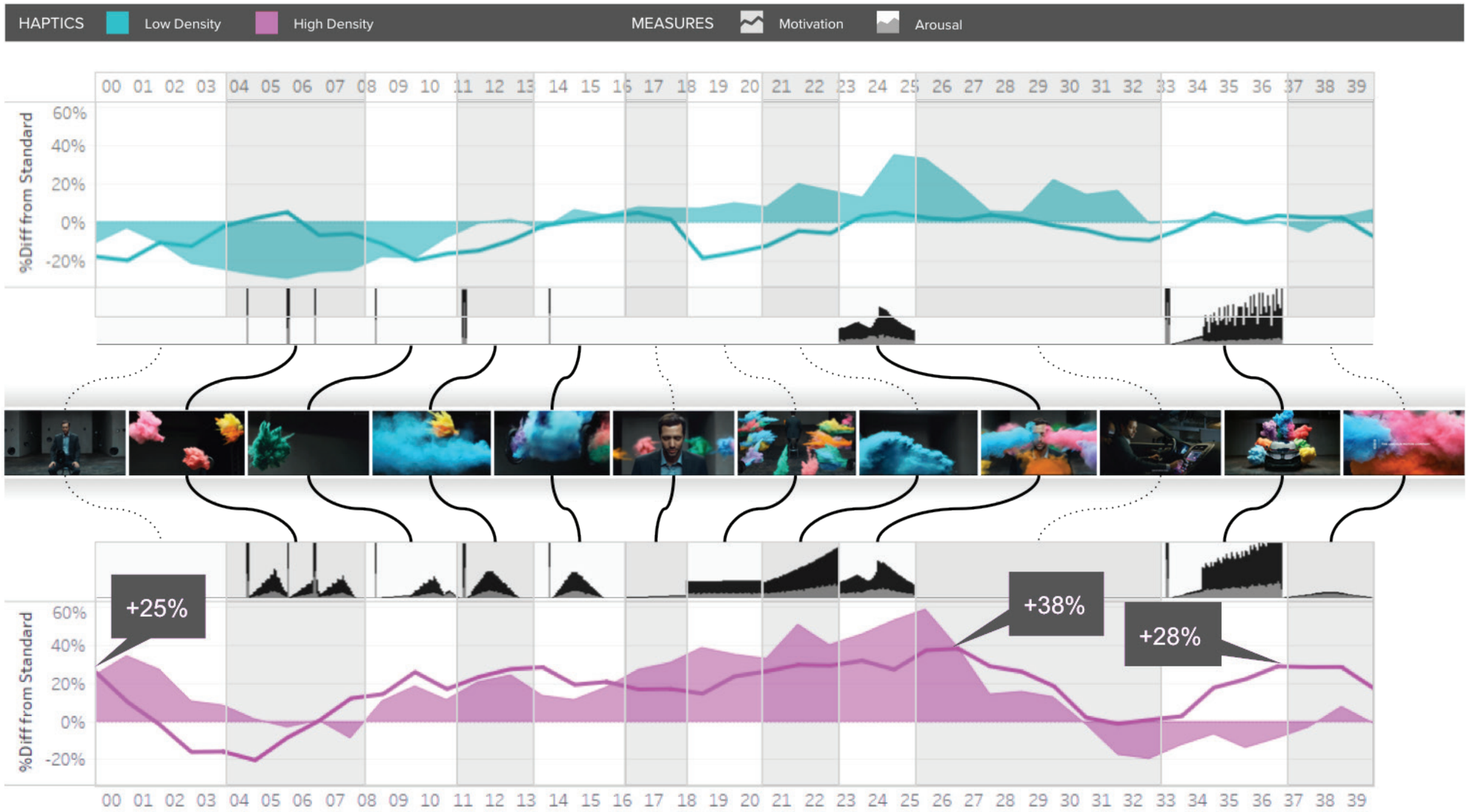
When we looked at how the brain reacts to touch, research subjects were more open to persuasion when they experienced haptics. An experience with haptics elicits 5% higher motivation on average, relative to a standard experience without haptics, measured by the increased activation in the Orbitofrontal Cortex and Ventral Striatum in the brain.

It is our view that when comparing to a non-haptic experience, haptics show the greatest impact on boosting emotions. This is further enhanced by ease of understanding and low cognitive load from high density haptics – a design treatment with strong and ample effects throughout the experience.

In our experience, the key to effective haptics for each use case is knowing which design approach and density will resonate best with the specific audience. To understand which design approaches yielded the strongest brain effects, we looked at the visual and auditory context for each experience.

In a scene involving sporting goods and active people, our respondents reacted more positively to low-density haptics, a design treatment that is subtler with effects spread throughout the experience. Subtle haptics helped make stories about sports and activities more appealing and easier to grasp. On the other hand, high-density haptic treatments are more effective in automotive scenarios where haptics convey power and excitement. With cars, the human brain associates high-density haptics with the sound and feel of an engine, resulting in higher appeal, emotional intensity, and arousal.

One of the fascinating outcomes of this study was witnessing the immediate effect of haptics as they were experienced. When we reviewed the content timeline, we were able to pinpoint the moment when haptics increased motivation and arousal in the subject's brain.



TIMELINE ANALYSIS

Haptics have the greatest effect when they match the pace and energy of an accompanying visual; for example, short bursts for fast, energetic scenes, and long and gradually progressing effects for slow motion.

Knowing that haptics intensify emotions, either positively or negatively, is useful in determining what imagery to pair with what type of haptics to achieve your design goal.

a clinging personality

she's touchy

itching to go

hands-off policy

she's tactful

a touching experience

he's tactless

a gripping experience

solid reputation

only scratch the surface

get a grip

make contact

grasp the idea

You already tell stories with touch — apply what you know!

can you handle it?

touch and go

a palpable lie

hold your own

a rough character

makes my skin crawl

the personal touch

be on your toes

don't be pushy

standing on pins and needles

I feel edgy

a slimy character

I'm deeply touched

stretch your imagination

HOW DO WE START WITH INTEGRATING HAPTIC DESIGN?

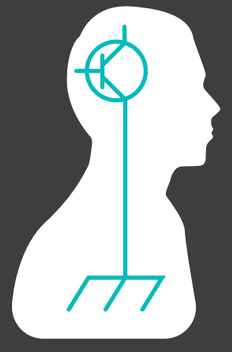
We can start with what we know.

We already tell stories with the sense of touch by using words having to do with touch. Let's look at what they mean for haptic design ideas.

Imagine we are designing haptics for a mobile phone targeted at utility users, such as service vendors, construction workers, or people who work outdoors. The brand elements that we would likely want to associate with the phone are ruggedness, toughness, and durability. We can consider applying haptics that imply the same type of characteristics, such as effects that are strong and distinct.

Another example is using themes of human hands interacting with objects and other people to convey values associated with high-touch service and personal touch. Haptics should match the visual, so viewers can feel what the hands are feeling. This makes the imagery more powerful and effective.

The most intuitive haptic applications are the ones that complement natural interaction – sometimes, without users noticing them. For example, haptics can replace a mechanical button on a mobile device, making it more customizable and durable for the mobile device maker.



EMBODIED COGNITION

The idea that our cognitive processes are grounded in sensory behavior and motor actions

This works because of a phenomenon called embodied cognition.

Our perceptions are grounded in what we feel and do. Most people don't realize that it is difficult to think independently of what is happening to our body. If we hold a warm drink, we'll rate the personalities of the people around us as "warmer." The same applies to coldness.

We can use haptic cues to affect the way people feel emotionally, which leads to a change in the way they think. This makes haptic technology a powerful tool for engaging both the bodies and brains of our audience and target users.

WHAT CAN HAPTICS DO?

There are six different groups of haptic design effects. These groups are based on the way they influence the user.

Attention Shift

Gracefully transition your customer's attention

Haptics are effective at shifting our attention from whatever we're doing to something new. If the user is busy with a primary task, and we want to interrupt him effectively, we can use haptics to break his concentration and draw his attention. In cars, for example, where getting the user's attention is critical and time sensitive to driver safety, haptics may be an effective design option.

Hedonics

Create sensations that feel good or bad, often prompting action

Touch sensations can range between positive and negative. Imagine the difference between a light flutter that feels warm and inviting, compared to a harsh buzzing sensation. Hedonics design is all about using these good or bad feelings purposefully based on the intention to affect the user. Hedonics design may be an effective method of eliciting an emotion or a response from the user as part of the perceived user experience.

Delightful Moments

Surprise your audience with bite-sized whimsical moments

As designers, we are often looking for ways to create delightful moments for our audience and haptics can serve this purpose. Haptics may be used to add pleasing effects to the user experience, such as when a friend messages us with a heartbeat emoji, and we feel the heart beating. In that moment, haptics are used effectively to intensify emotions and feelings of happiness. The effect is delightful because it's unexpected and cool.

Sensory Immersion

Make people's touch sensations match their visual and audio experience of an environment or brand

In entertainment media such as a movie, augmented reality, or virtual reality, the primary goal is to immerse the user in the experience. The best way to do this is to create content that is rich in sensations. Touch can be used to create an immersive sensation and haptics can augment these experiences in the digital space.

Information Flow

Transmit information through the sense of touch

There are use cases where it is inconvenient to access the screen or speaker, and haptics are the only option for communicating. Let's say that we are designing a fitness wearable, and we want to tell the user that she has passed a mile marker. We could use haptics to convey that information reliably without needing other modalities to deliver or reinforce the message.

Illusion

Simulate real-world touch experiences

When we want to trick people into thinking that they're having an accurate touch sensation of something that's not there, we're creating a tactile illusion. This is exceedingly difficult to achieve because the sense of touch is multimodal and complex. However, a true tactile illusion is highly rewarding and can broaden design possibilities for devices and content.

APPLYING HAPTICS IN UI

A quality haptic experience can have a positive impact on the user's impression of the device and brand.

Touch is an ever-present aspect of interacting with any consumer device. With haptic technology, device makers can take a more active approach in owning the touch experience of their device. When haptic design is done well, consumers perceive the entire device as having a higher quality user experience. When done poorly, haptic design can negatively impact consumers' perceptions of the device and the brand.

We recommend pre-defining your use of haptics as a part of your design language o help maintain a consistent quality of experience throughout the device and across the product portfolio. Having pre-designed conceptual design guidelines make it easier to use haptic effects effectively in the user interface and use case applications.

Good haptic design language complements and extends to the visual, audio, and industrial design languages so that the device feels like a cohesive product. It should also represent the brand and speak to the product's target market segment.

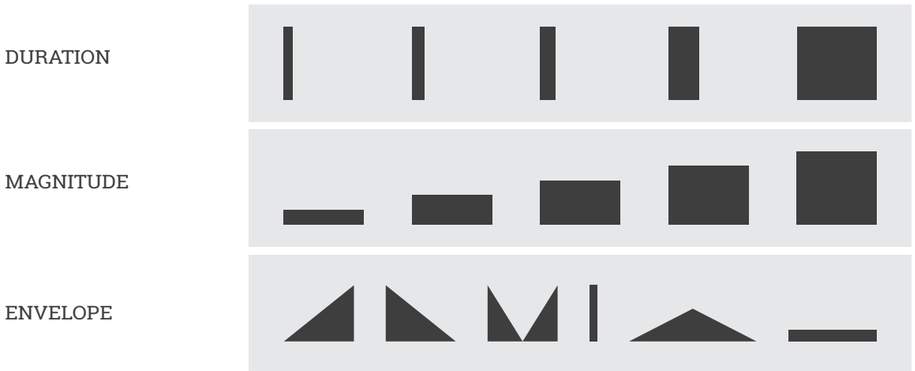
Below are some basics principles for haptic UI design:

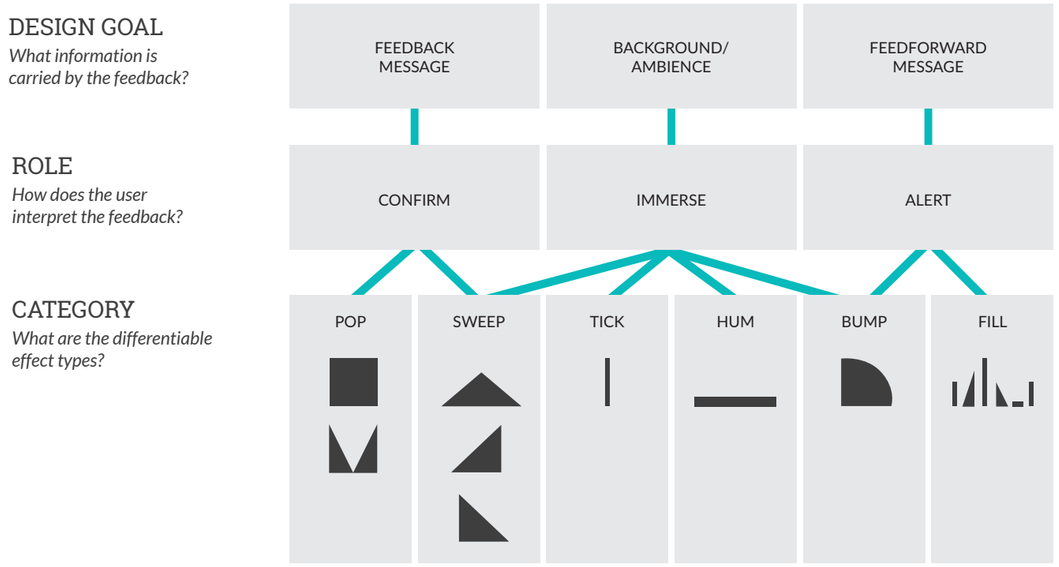
Parameters of SD vibration:

- Duration, measured in milliseconds
- Magnitude, measured from 0 to 1
- Envelope, which refers to magnitude contour over time, measured in duration of envelope stages called ADSR (attack, decay, sustain, and release)

Design goals for haptics in digital devices:

- Confirmation effects: To provide feedback to the user that some action has been taken
- Immersive effects: To form part of the background or structural design of the UI
- Alert effects: To provide a feed-forward message intended to interrupt the user about something important





Use these effect categories can to achieve specific design goals:

- A pop is a short duration, strong effect with one magnitude peak. A click is a type of pop with two peaks.
- A sweep is a medium duration, medium magnitude effect with an envelope that rises in magnitude, falls or does both.
- A tick is a very short, light effect. Useful for detents (or notiches) in a widget, or in the case of narrative content, raindrops, rustling leaves, and so on.
- A hum is a low magnitude, ongoing effect useful to communicate about an ongoing process.
- A bump is a long pop with a decaying envelope, useful for getting people's attention and accentuating collisions.
- A fill is a short sequence or pattern with a complex envelope, often matching a short sequence of audio or visual accompaniment.

APPLYING HAPTICS IN VIDEO

Haptic effects in video enhance the entertainment value by making the content more immersive and engaging.

By adding another human sense to an experience, haptics heighten our body's receptivity to the other senses. In video content, this translates to an increased awareness of sounds and visuals, resulting in an experience that is more vivid and memorable.

We've learned that the key to using haptics in video is to match the haptics with the story's goals and messages. Based on insight from several user studies on short-form video content, we've developed general haptic design approaches that can be applied across a variety of content types. The studies; ranged from focus groups and in-lab neuroscience studies to demo surveys and behavioral studies, and produced trending qualitative and quantitative data points on users' preferences and responses to haptics in video.

Although each design approach below is presented alongside a specific example of a content type to which it applies, the guidelines should be understood as universal best practices.

Understand how to impact emotion and rhythm

Haptics can elicit negative emotions when paired with aggressive visuals, such as the robotic syringes in one of the study's tests videos. Haptics can trigger positive emotions when paired with exciting visuals such as the sound and image of an engine starting, or an exciting driving sequence.

In the case of repeated and isolated actions, such as bursts of colored clouds shown to study participants (see p. 16), haptics can significantly improve appeal – especially when synchronized to the beat of an audio track.

Be intentional and strategic

Focus haptic moments on key elements having to do with the brand, product, or idea. During a shower scene promoting a personal hygiene product, for example, haptic effects applied to water splashes may feel great; however, it is a distraction to the product featured and is ineffective.

Get creative and cinematic

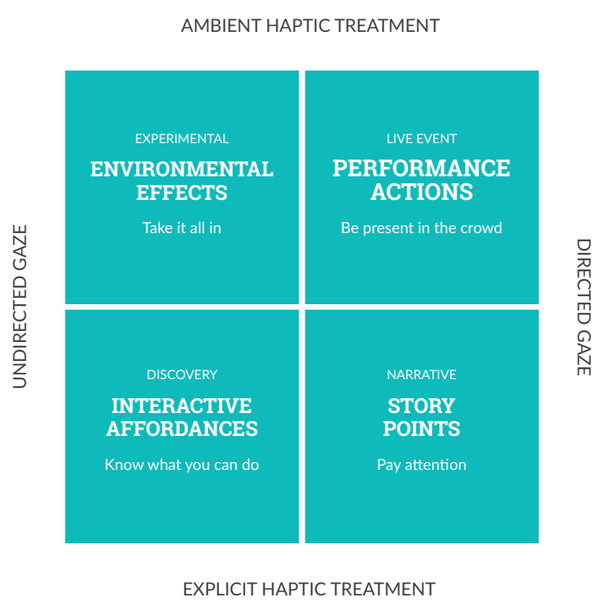
Focus on movement in the video to create interesting cinematic effects and align haptics to the message. We found that the brain immediately engaged with anticipation when haptics accompanied a strong visual effect, such as the breaking of metal chains or a swarm of bees over a city.

360 HAPTIC VIDEO

Creating haptic tracks for 360 videos is uniquely challenging. As designers, we must consider the way people view the video and how the story being told. Depending on how the story is designed, haptic effects can be used to emphasize characters, scenes, or the point of view of the user. Defining the best match to target for haptics is critical to having an optimal outcome.

Adding to the complexity, 360 videos are navigated in three ways – with fingers, by moving the mobile device around, or by connecting the device to a headset.

Use the framework below for guidance on how to approach a haptic track for a 360 video.



HAPTICS IN VR

In virtual reality, haptic design approaches are more straightforward. Users have high expectations for a quality VR experience. Users want to truly believe in the reality that they are seeing, and feeling virtual tactile sensations is a big part of it. The goal in VR should always be to create sensory immersion and illusion.

In tomorrow's VR experiences, interacting with virtual objects will play a central role, and haptics will be required to complete the experience. The good news is that perfect simulation of the real tactile properties of an object is not necessary. When we experience a multi-modal stimulus – a stimulus that triggers a response in multiple neural sensory channels all at once – the brain fills in the gaps to complete the experience; as a result, we interpret it as real. Haptic design for VR is, therefore, crucial to making things feel like they sound and look, to build up the belief that something is real when it isn't. However, haptics do not need to be 100% realistic to achieve this.

Present Interactive Affordances

Affordances, or opportunities for action within an environment, are important in interactive experiences like games. Haptics can help inform users about which parts of the virtual environment are interactive. By leading the user through a sequence of pre-defined interactions, haptics make VR more user-friendly and convey the designer's intent seamlessly.

Enable Object Interaction

While a comprehensive tactile design for VR space is not possible with today's hardware and software limitations, we should look for haptic opportunities that can make the design a truly immersive experience. Users should be able to interact, manipulate, and touch virtual objects to give them a sense of presence or to get critical feedback about the state of an object in the virtual environment.

Import Design Best Practices From Legacy Media

In many cases, VR is much like video content, so we can use best practices for haptic video in VR. Similarly, some game mechanics in VR borrow from traditional mobile and console gaming; therefore we can apply similar haptic design approaches in VR. However, as VR becomes more mainstream, new techniques and best practicses will emerge that will be more suited for VR.

DESIGNING HAPTICS

There are many ways to design haptics. However, the key to a great haptic experience, and therefore a great user experience, is to purposefully use haptics in the right conditions to communicate the message. For example, in the mobile device environment, we need to pay attention to the design intentions behind the use cases, the device's capabilities, and user behavior.

Keeping the principles of good haptic design in mind, we can use haptic design tools to create the haptic experience. It's helpful to understand the different types of design tools: timeline-based for video, animation-based for UI, and a combination of both for gaming.

Timeline-based tools are like audio editors; haptic effects are arranged and synchronized to other media, such as audio and video tracks. Multiple haptic tracks can be applied to different haptic actuators, or mixed down and rendered on the same actuator.

An action-based tool delivers effects that can be called upon throughout the experience. These tools should make it easy to apply effects consistently, and reiterate and stagger effects as needed. Because the haptic effects do not need to adhere to a timeline, there is more freedom to the effect design. With an action-based tool, we can add effects such as barrel rolls or boost.

A good creative tool enables us to play, experiment, and iterate quickly. In the case of haptics, this means supporting essential functionalities, such as live monitoring, iterations, and enablement of rapid creative review by stakeholders. Also, the ability to "design once, play everywhere" is a key feature of any haptic design workflow.

While both timeline-based and action-based tools can be used interchangeably, we need to pay attention to the experience and what tool we are using to avoid creating an experience that is mismatched.

Haptics can bring great value to an experience when properly designed in the right context and with an intended experience in mind. Learning about haptic design can add depth, improve overall design approach, and help us more effectively tell our story, whether it is for a product, a game, or in a video.

LEARN MORE ABOUT THE STUDY.

To download the research paper, "Discovering True Emotion in Haptic Tech: A Study in Motivation and Arousal," go to http://go.immersion.com/Whitepaper-Discovering-True-Emotions-in-Haptic-Tech

Check out Immersion's Haptic Web Gallery
(View on Android Chrome to feel haptics)

Download Immersion's Content Portal App on Google Play

For more information on haptics go to www.immersion.com

ABOUT THE AUTHORS

Sanya Attari, Manager of User Experience Research at Immersion Corporation, leads research activities in a wide variety of verticals involving physical interactions, including smartphones, wearables, gaming, and automotive interfaces as well as content-based interactions and advertising. Her research background includes qualitative and quantitative user experience research at Cisco Systems and pervasive computing academic research during her Ph.D. studies at Virginia Polytechnic Institute.

David Birnbaum, Director of User Experience Design at Immersion Corporation, has been creating haptic experiences for over 12 years, in which time he has been named as an inventor on over 70 patents in the fields of user experience, wearables, gaming, medical devices, mobile communication, and rich interactive media. A leading expert in haptic design, he leads a team responsible for developing the tactile aesthetics of emerging technologies. David is driven by a desire to tell stories with the sense of touch and to bring emotion and realism to digital experiences. He holds a B.S. in Music Industry from the University of Southern California and an M.A. in Music Technology from McGill University.