Constructing Fidgeting:

Integrating Extended Cognition, Mind Wandering, and Mindless Interaction in Pursuit of a ‘Productive’ Mood

Author

John Anders Eichenlaub

Master Thesis

MSc. Integrated Product Design
Faculty of Industrial Design Engineering
Delft University of Technology

Supervisors

Chair: Dr. Haian Xue
Assistant Professor
Faculty of Industrial Design Engineering

Mentor: Dr. Gijs Huisman
Assistant Professor, Embodied Interaction
Faculty of Industrial Design Engineering

TU Delft

DELFT INSTITUTE OF
positive design

Acknowledgements

One cannot condense into a few short sentences the impact that others have had on their life. In this often isolating and individual graduation project, I found renewed importance in these relationships.

This work is created in recognition and honor of those people and relationships that give me meaning. I could write many more words, but the rest of this report itself is long, so I will exhibit some restraint.

This thesis is...

For my parents and family, without whom all that I have, and all I have done, could not be.

For (and with) Haian and your compassionate advice, willing conversation, and mentorship. 衷心感谢您的谆谆指导。

For (and with) Gijs and your incisive feedback, project-shaping contributions, and mentorship. Hartelijk dank voor uw begeleiding.

For Jens, an engaging conversationalist, insightful sounding board, and great friend. *air horn noises*

For the InventiveProjectDreamers (Adriaan, Asli, Kevin, Natalie, Parastou, and Tessa), keeping us all grounded and supported in uncertain moments.

For the StudioLab community, who graciously welcomed me in and made for enjoyable lunch dates.

For my Force Elektro teammates, my social community here in Delft.

For the sum collection of past and ongoing friendships and relationships that have constructed, defined, and opened my world.

Finally, for myself. As present-day poet and philosopher Snoop Dogg said, "I wanna thank me for believing in me. I wanna thank me for doing all this hard work... I wanna thank me for just being me at all times. You a bad m—f—."

Abstract

Object-mediated fidgeting (pen clicking, ring spinning, paper folding, etc.) is a pervasive and often unaware human behavior. Despite its prevalence, fidgeting has no consensus cause or effect in existing scientific literature. This graduation project seeks to operationalize fidgeting through and with design to enable affect self-regulation, or the recognition and modification of emotions and mood states. In particular, the Fidget Spheres concept and prototype aim to move users towards a "productive" mood state. Further, we consider the use context as traditional offices and higher education, in situations such as a lecture, conference meeting, quiet desk work, or a video call. Key project outcomes are "constructed" – both a physical prototype and future concept, but also a theoretical landscape of fidgeting.

The project began with a literature review, launching from the topics of "somaesthetics," emotion, and interaction design. While somaesthetics is not the guiding principle for the final design concept and generated knowledge, it served as a vehicle to introduce many relevant topics, such as embodied interaction, extended cognition, implicit and explicit interaction, affective loops, and mind wandering. Research into these disparate domains, once synthesized, yielded key takeaways that informed concept directions and desired interaction characteristics for later development.

After acquiring a theoretical background, three research activities were conducted to better understand both fidgeting and affect. A three-person introspective experience scanning exercise yielded early insights about the intent of fidgeting. Next, analysis of a short-response survey on stress coping mechanisms revealed common mechanisms and strategies for affect self-regulation. Third, an intensive Reflexive Thematic Analysis (RTA) was conducted on a large public data set of 'Fidget Widgets' and use descriptions. These study results, taken alongside the literature review, drive our theory of "Reflexive Focus Bounding" and the embodiment of the Fidget Spheres prototype and concept.

Concept directions were loosely explored before settling on "Fidget Spheres," a

set of handheld spherical fidget objects inspired by Chinese Baoding meditation balls. This simple and adaptable platform allows for future iteration and development of interaction and haptic feedback modes. The prototype was used to embody specific interactions with responsive vibration feedback and was evaluated by six participants in a focus group session. While prototype development was not finished during the project term, rich insights from literature, data analysis, and prototype testing were still sufficient to create the final concept vision for Fidget Spheres. The concept video details the use case, effects, and interaction characteristics for the envisioned and optimized Fidget Spheres.

This graduation project constructs both a fidgeting design space through synthesis of cross-disciplinary knowledge, and an embodied prototype to enable affect regulation through established 'mindless' or implicit fidgeting behavior. Future work can conduct more detailed analyses of the perception of varied feedback modalities in-situ, as well as prove (or disprove) the proposed Reflexive Focus Bounding theory. The prototype could be evolved with "personalization" protocols and the implementation of other haptic feedback modes.

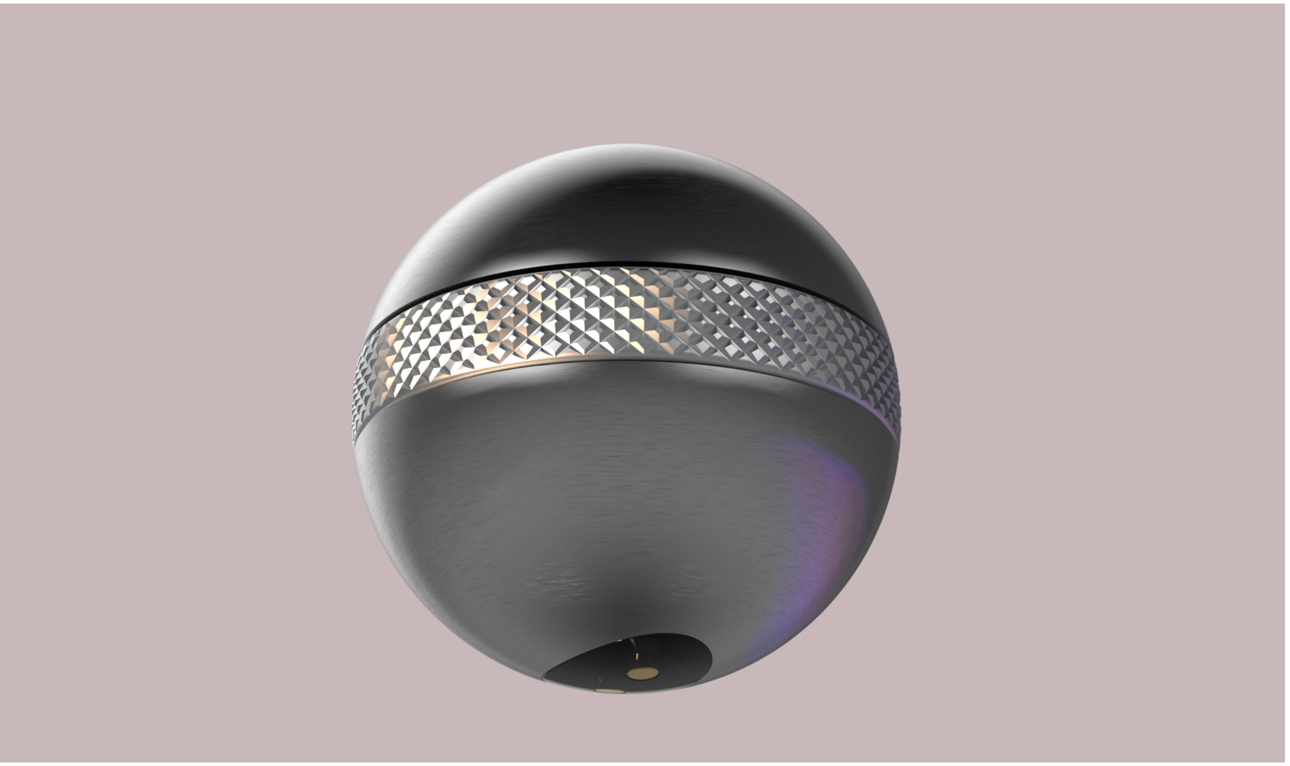


Figure 1. Render of envisioned Fidget Spheres concept

Table of Contents

1. Introduction

1.1. Background Information and Project Context

Project Raison D'Etre

Younger generations are increasingly focused on "experiences" over "possessions," attempting to secure meaningful life experiences in the face of rising global and personal instability. As such, meditation, yoga, and other activities that support mindful emotional presence are popular and growing. There exists a design opportunity to create a product that seamlessly augments our own capabilities of emotional regulation and perception in a robust and reliable way. As more and more people seek an emotionally rich and fulfilling experience, the needs for aid in these same pursuits grows along with it.

To be clear, many products do exist in this space that purport to support somatic and emotional wellbeing, each with variable scientific foundation and efficacy. This project distinguishes itself for a rigorous scientific process alongside creative and insightful product embodiment, as well as a specific attachment with the concept of "fidgeting" behaviors. The author recognizes that in a space as complex as human affect, no one product or service will be a universal solution. Still, this need for mastery of our own lived experience is a significant motivator and renders this design pursuit valuable and viable.

This trend is further strengthened by the ongoing coronavirus pandemic and the related lifestyle changes unexpectedly forced upon most of the world, such as working from home or even the loss of employment, partners, and stability. Many people are inarguably more stressed and anxious than before, and frequently find themselves left alone to deal with those emotions. A tool that allows for independent emotional self-regulation is thus much more immediately relevant than in the near past.

As this project evolved, we narrowed focus onto a specific target mood state, seeking to enable a transition into a "productive" state. It is still likely, however, that the insights from this project could be broadened to emotion and mood regulation in general given some adaptations.

Fidget Devices

One of the most dominant trends of 2017 was the "fidget spinner", a 3-lobed plastic toy (see Figure 2) that spun on metal ball bearings. Instantly popular amongst kids and students, the device was purported to help with concentration, among other benefits. Due to its explosive popularity, related devices later entered the market, from "fidget cubes" to "infinite" bubble wrap and numerous small toys predominantly made in Asia (Figure 3). Scientific research draws conflicting conclusions as to the efficacy of these devices for emotional regulation, attention, and fine motor control. Some studies report increased attention in users with ADHD, while many report no or adverse effects on learning and memory (Cohen et al., 2018; Schecter et al., 2017; Soares & Storm, 2020). Quickly fidget spinners were banned in classrooms worldwide for the nuisance and health hazards they created, specifically around accidental ingestion of batteries on certain models and high lead concentrations in others. Even given these less-than-stellar attributes, some related devices and toys remain popular.

Figure 2. Example of protoypical fidget spinners, own image

The existence and the enduring trend of "fidget objects" speaks to an underlying need and desire of a large target group: persistent tactile interaction that helps self-regulate behavior (or at least is perceived to help). Fidget devices themselves are often small, portable, and technologically "dumb," enabling continued use without chargers or electricity. Their inherent ubiquity makes them attractive as the focus of a design project and leaves open many possibilities for improvement.

Figure 3. Contemporary Fidget Objects available for sale, own composite image

Somaesthetics

This graduation project began as extending from a relatively contemporary philosophy called "somaesthetics," which was developed in the mid-1990s by Richard Shusterman. Somaesthetics rejects the mind/body dualism found in classical philosophy (and historical interaction design) and instead considers one united whole, with experience and emotion inseparable from our bodily experience. In his 2020 paper "Somaesthetics in Context", Shusterman "outlines the roots of somaesthetics in pragmatist philosophy and the philosophical idea of the holistic art of living" (Shusterman, 2020, p. 245).

Somaesthetics has already been introduced into the design space, primarily in the Human-Computer Interaction (HCI) field by researchers such as Kristina Höök. She views the primary purpose of somaesthetic design as "making people more aware of their felt bodily experiences" (Höök et al., 2015). Somaesthetics was very closely linked to the initial research questions proposed in the graduation project brief, however, as the project evolved it became less relevant. The general attitudes and perspective explained above remain relevant, but the detailed design frameworks that come from somaesthetics were not used. As such, detailed research into somaesthetics has been removed from the main report body and is contained in Appendix B.

Human-Computer Interaction

As a field of study, human-computer interaction covers significantly more breadth than popular perception might believe. This graduation project falls squarely within the bounds of HCI as it is currently studied and presented in preeminent academic conferences and journals such as the ACM Conference on Human Factors in Computing Systems (CHI), Designing Interactive Systems (DIS), and more. The exact knowledge and theory under study with this project is reviewed in the following chapter, Theoretical Background, but the author felt it important to situate this work within a specific field of study in this introduction.

Introduction Takeaways

We can see that fidget objects receive conflicting reports of efficacy for emotion and attention regulation, yet such objects remain in popular use (whether designed for that purpose or not). Additionally, most are very cheaply made “dumb” devices. There is an appreciable design opportunity to validate mechanisms of emotion and attention regulation and embody them in an already-popular class of devices (fidget objects). The research questions are constructed to direct effort towards the most relevant and yet-unknown knowledge needed to meet this goal.

1.2. Research Questions

This graduation project has a considerably open scope as defined in the project brief. As emotion regulation and somaesthetics are both quite abstract and difficult to quantify, a more restricted scope including quantifiable metrics of success was not relevant for this project. The original research questions (from the project brief) captured a focus on broadly regulating emotion through tactile interaction and embracing the “art of living” element of somaesthetics. Importantly, these questions evolved over the course of the project, and ultimately were not used to structure the project outcomes and design. Those initial questions are reproduced below:

Former Research Questions -

> *RQ1.1 - What (tactile) sensory interactions contribute to effective emotion and mood regulation, especially of “undesirable” emotional states?*
>
> *RQ1.2 - Can tactile interaction contribute to deeper perceptual awareness of one’s own body and bodily experience?*
>
> *RQ2 – In what ways could deeper perceptual awareness (mindfulness) and connoisseurship of the lived mind-body experience benefit people’s emotion and mood regulation?*

It is more representative to evaluate the research and project outcomes based on the following research questions, which reproduce the core of the originals but with a more targeted and restricted scope. One can notice a transition from “mindful” to “mindless” interaction in question 2; this apparent contradiction is an important point that emerged from our investigations. Further, we discard any mentions of somaesthetic principles in the new questions. The finalized research questions are:

> *1.1 – What (tactile) sensory interactions can contribute to effective affect self-regulation, specifically of negatively valenced states?*
>
> *1.2 – Can tactile fidgeting behavior precipitate an awareness of one’s lived, bodily experience?*
>
> *2 – How does implicit “mindless” physical activity promote wellness (as compared to explicit “mindful” activity)?*
>
> *3 – How can we conceptualize and understand the benefits of fidgeting behavior?*

These four research questions will be reviewed in the concluding sections of this report, with an aim to answer all of them through the project research and design activities.

1.3. Research Methods

This graduation project can be characterized as having two predominant research and design methodological approaches at the core: first, Research through Design (RtD), and second, "Introspective Design" methods. It is very important to clarify that these approaches are not mutually exclusive; in fact, both can be used in conjunction to extract the maximum potential from either method. Each approach is briefly explained below, specifically with a focus on relevance for this design project.

Research Through Design

RtD was formalized within the Interaction Design and HCI communities with only 15 years ago with a foundational paper "Research Through Design as a Method for Interaction Design Research in HCI" (Zimmerman et al., 2007). While the idea of practice-based research was not wholly new or unfathomable (see Desmet et al., 2001, for just one prior example), this paper and following efforts marked a significant shift in mindset for HCI and design researchers. This broad acceptance of scientifically valid processes involving iterative prototypes allowed for later introduction of somaesthetic design methodology, autobiographical methods, and more. RtD readily accepts the generation of knowledge that is derived from speculative prototypes and their evaluation in real-world scenarios.

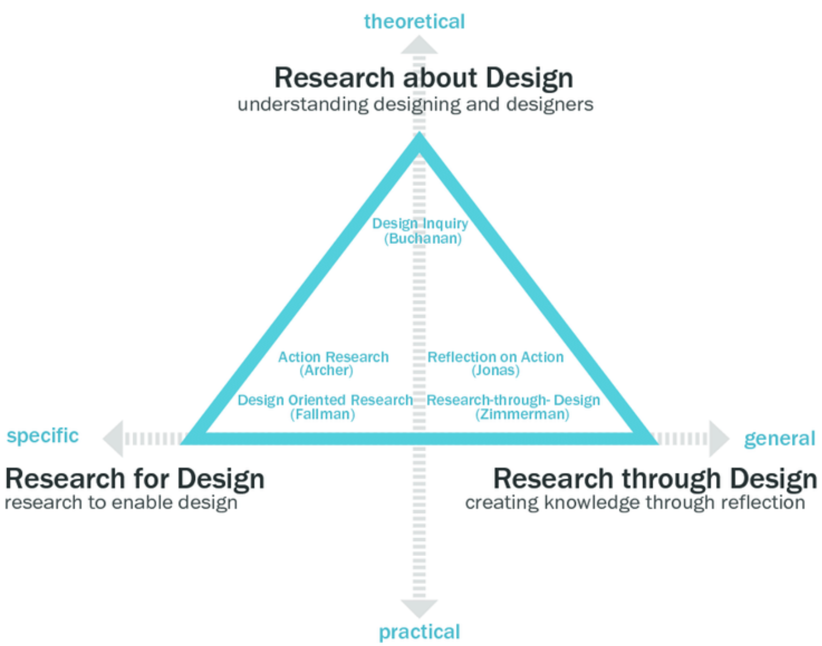


Figure 4. Positioning of RtD as an approach. Tieben, 2015

Research through Design is not simply a haphazard presentation of prototypes, but rather has both requirements and specific objectives. As originally presented

by Zimmerman et al. (2007), RtD "allows design researchers to collaborate on an equal footing with HCI engineering and behavioral science researchers." The same paper also proposes four "evaluation criteria" by which a RtD exemplar can be evaluated: process, invention, relevance, extensibility. RtD allows for the creation of design artifacts that embody technical research, but are easier to see, learn, and accept for HCI practitioners in the field, thus transferring knowledge between domains.

This graduation project aims to create a prototypical result of a RtD process, synthesizing diverse technical knowledge to address a vague and complex issue through a functional example product/service. Defining the "end" of an RtD process is challenging, as it can involve multiple generations of research artifact. Therefore, we recognize our process will be limited by the time limit of graduation and not by reaching a certain fidelity of design.

Introspective and Autobiographical Methods

Introspection, or the internal examination and understanding of one's own thoughts and emotions, is a challenging yet natural human process. To deny it's value (or even existence) in the design field is to do a disservice to the entire body of lived experience a designer-researcher has developed over their life and career. This project seeks to embrace introspective methods such as autoethnography and subjective qualitative analyses as a valid design research pursuits and reveal their value in the process.

In traditional user-centered design, designers themselves often were told to set aside their own "subjective" judgments for a more "objective" result of user studies and aggregate data. The recent "Experiential Turn" reframes the domain of industrial design to focus on the experience and emotion involved with product interaction (a departure from the more physically oriented "affordances" and requirements of Norman's user-centered design (Norman, 2013)). In this movement, designers have been rediscovering the value of self-analysis and introspection in design. Turning inward towards one's own experience can offer critical insights in designing for abstract and complex concepts like emotion and experience.

If a designer is a "complete member" of a group, meaning they can fully represent that group in terms of experience and knowledge, they can and should be seen as a valuable and suitable design resource. Introspective design methods

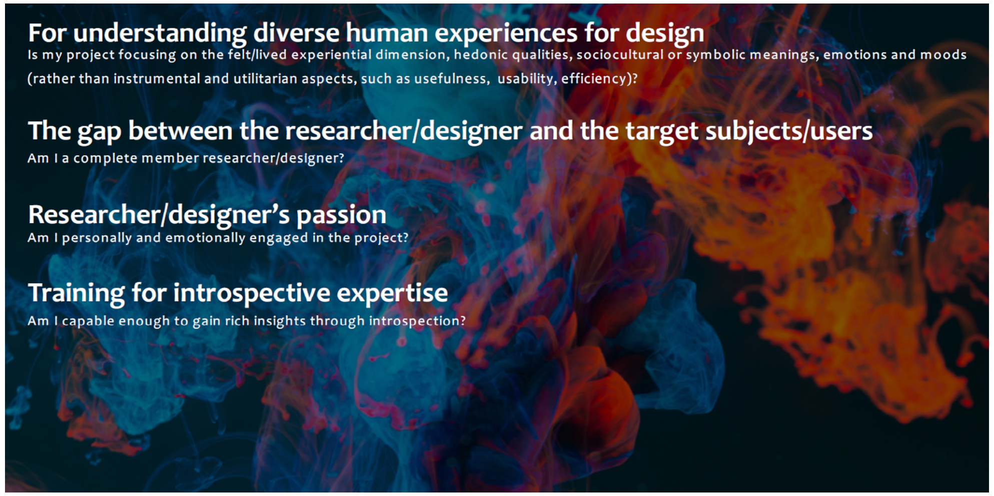


Figure 5. Four Preconditions for use of Introspective Methods. Xue, 2021

seek to remove the stigma around utilizing the "subjective" self to influence and guide design efforts. The application of introspective methods does not allow designers to completely ignore external users of products, rather, introspective methods can be one tool in the tool belt, allowing for design that can reach an intimate emotional and experiential impact. In a course lecture, Haian Xue laid out four key requirements for the use of introspective methods: 1) The project/research must focus on felt and lived experience, emotion and moods, or hedonic qualities, etc., as opposed to utilitarian aims. 2) "Complete membership" of a cultural group as described above. 3) A personal engagement or passion for the subject. 4) Enough training and expertise to apply intensive introspection and derive insight from it. Given the focus of this project on fidgeting (an almost universal behavior) and its effect on affect, the above four criteria very clearly suit the project, and the author can retrospectively confirm that they met all four of these criteria during this project (or at least the first three and a half).

Many benefits can be derived from centering a designer as the origin of design insights. First, the designer/researcher/subject is always available for consult. There is also no doubt of the veracity of statements or experience if the designer is honest with themselves. Time restrictions of user studies are also not a problem. Traditionally, academic research sought objectivity and constructed a strict divide between the researcher and their subjects. Recent proposals suggest that most research in design already contains subjective, designer-centric introspection that is veiled behind the objective façade of the scientific process (Xue & Desmet, 2019).

While designers and researchers themselves may be optimally positioned to leverage introspective methods, traditional "user" and study participants can also make use of these methods through autobiographical processes. Journaling or diary writing and audio and photo recordings, among other things, can allow an unfiltered look into the life and actions of a participant as seen through their own personal worldview. Methods such as Experience Sampling can be reformulated to allow participant self-recording, thereby eliminating biases that emerge in the formal structure and setting of research and the time investment of interviewing. The growing acceptance of the subjective in design research (as earlier mentioned) permits these sorts of methods a space within literature and academia and makes introspective methods suitable for application in this project.

Research Methods Takeaways

Research through Design enables the scientific reporting and sharing of knowledge developed primarily through the design process (inverting traditional knowledge transfer processes). Designer-centric (introspective) processes open the constant and immediate availability of depth and expertise for informing a project. Importantly, introspective methods are not a substitute for user-centric methods when designing a product; rather, they are two complementary forces that engage to create more appropriate and effective design. This graduation project bases its foundations in these methodological principles and trusts in their scientific acceptance and validity.

1.4. Project Aims and Reporting

The project aims are directly derived from the research questions, but allowance should be made for the evolution of aims during the project. At their most concise, the project aims are as follows:

- Understand fidgeting behaviors as they appear in school (university) and office environments.
- Determine what affective change a smart fidget object could effect on users.
  - Understand what interactions and feedback could precipitate this change.
- Prototype and test a smart fidget object in a research-through-design-like process.

- Envision an optimal future concept.
- (Perhaps most importantly) clearly communicate the learnings on the fidgeting design space and the potential value of a smart fidget object for promoting a productive mood state.

This master's thesis report is largely written in four successive phases, each covered by one major chapter: first, literature analysis was conducted over a variety of fields (*Chapter 2*). This was synthesized into new knowledge, driving the Reflexive Focus Bounding theory, and informed the applied research activities. The next main chapter (*Chapter 3*) covers the three analyses of data surrounding fidgeting experience and perception. The activities are individually motivated and described, and key takeaways are shared for each. *Chapter 4* presents the Reflexive Thematic Analysis writeup, which details the high-level conceptual view of fidgeting behavior as we know it. *Chapter 5* details translating these previously discovered insights into a physical prototype and evaluating that prototype with the target group. From the successes (and failures) of the exploratory prototype, *Chapter 6* covers the idealized future vision of the product in its optimal form, as well as a use scenario and desired interaction characteristics. The report finishes with brief conclusions and recommendations for future tests and development.

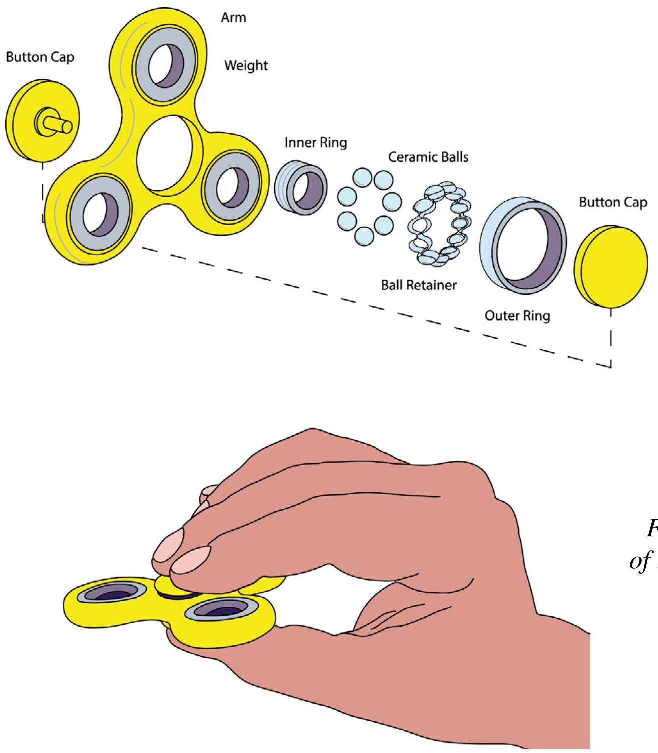


Figure 6. Decomposition of typical fidget spinner. Cohen et al., 2018

2. Theoretical Background

In order to fully understand the design decisions and processes followed over the course of this project, one requires a basic understanding of emotion and mood (together known as affect) and essential theories in interaction design. To best facilitate this knowledge, this chapter contains a section on each key topic that structure an appropriate knowledge basis for a reader new to these fields of study (as the author themselves was just a few short months ago). An earnest attempt has been made to avoid an extensive narrative lecture, and instead to provide only necessary information. For those curious to know more, the cited works in this thesis are all high-quality resources.

2.1. Emotion, Affect, and Regulation

2.1.1. Models of Emotion

Given the complexity and nuance of emotion, most theories are exactly that: theories. We may never know exactly by what mechanisms emotions are produced and interpreted, but many research scientists have attempted to so define them. Here we review some of the more popular and relevant models that have impact in this space and on this project. The dimensional models best inform our conceptualization of emotion as this project seeks to render positive valence and appropriate arousal through the use of fidget objects. However, the discrete models of affect like Desmet's typology are beneficial in structuring and communicating the design project goals and outcomes (P. M. A. Desmet, 2012). Above all, we accept Boehner and colleagues' proposal of emotion as arising from interaction and their philosophical stance on technologically enabled devices and their role in measuring and influencing affect (Boehner et al., 2007).

"Basic" Emotions and Moods

Many sources see the idea of "basic emotions" as emerging from the work of pragmatist philosopher William James at the end of the 19th century (James, 1890, 1905). The basic emotion theory posits that any one person has a limited set of basic emotions that are distinct from each other in their appearance and manifestation (psychologically and physiologically). As humans, we all have the capability to access and experience this set of basic emotions (Ekman, 1992). Early authors even suggested that each emotion would be represented through facial expression in a distinct way, though this was proven incorrect through a multitude of studies, both in isolated groups and across cultures.

While a “basic emotions” model may not completely represent the nuance of emotional experience in humans, they are clearly understandable, communicable, and do not require knowledgable interpretation. As such, they can be seen as useful in situations where emotion is to be designed for, or where we wish to observe, understand, and record the emotional experience of another person. Along these lines, Pieter Desmet has spent his career researching product experience and affective responses created through product interaction and has produced methods (P. Desmet et al., 2001), frameworks (P. Desmet, 2003), tools, and typologies (Figure 7) (P. M. A. Desmet, 2012; Fokkinga, 2015; Xue et al., 2020) to allow designers to leverage emotion in their interaction and experience design practice.

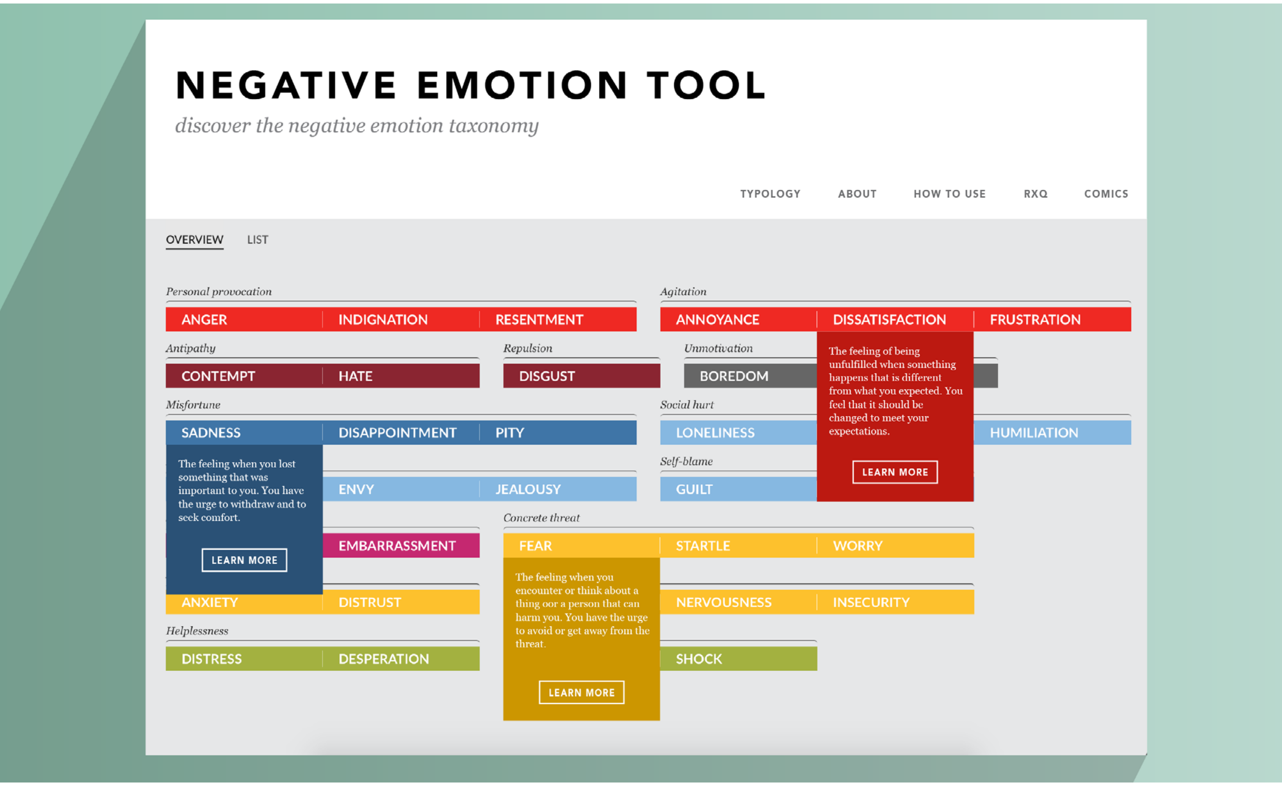


Figure 7. Negative Emotion typology online tool. From emotiontypology.com

Desmet’s work draws from the whole range of theoretical emotion models to inform the creation of these typologies and emotional response measurement methods, without explicitly casting one model as “correct.” His semi-quantitative evaluation methods reduce the barrier to entry for emotion-based design work. In his own view, these methods and tools allow designers to develop their own perception of distinct emotions and moods, as well as “specify design intentions in mood-focused projects” (Xue et al., 2020, p. 1). For this project specifically, we leverage the “typology of 20 mood states” to define our key outcome goals for the prototyping stage (an example is shown later in Figure 10). After our applied research, we learn that the “productive” mood state accurately describes the desired effects of a designed fidgeting object, so we leverage that to help constrain our explorations and define requirements in prototyping and concept development.

Dimensional Models of Emotion

Russell’s Circumplex Model of Affect positions affective states as coming from two neurophysiological systems that act independently but interact to define the space of affect and its manifestations. The two systems are related to “valence,” a positive-to-negative spectrum based on pleasure (so pleasurable or displeasurable) and “arousal,” or “alertness” by the original author (Russell, 1980). Any emotion can be plotted on the two-dimensional space formed by the spectra set on orthogonal axes, and specific emotions each occupy a unique (though sometimes overlapping) space. Thus, the circumplex model is a “dimensional”

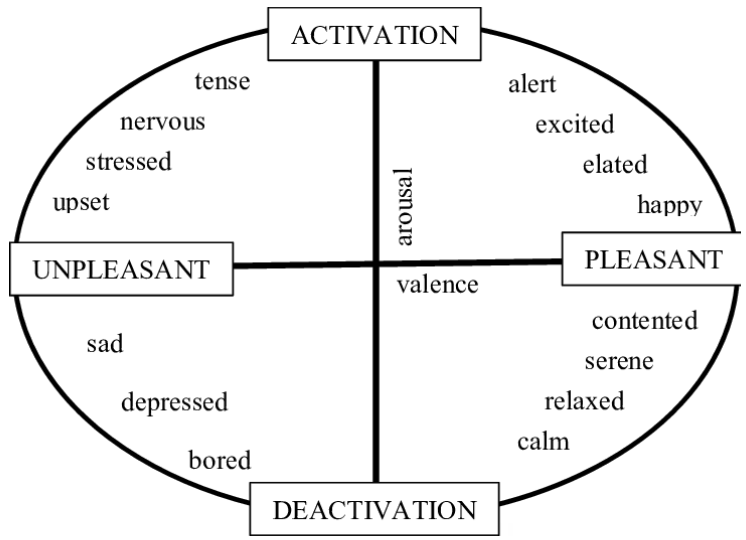


Figure 8. Circumplex Model from Korn et al.

model of affect, alongside the vector model seen later. For a visual explanation and relative positioning of key emotions, see Figure 8 from (Korn et al., 2017). Dimensional models are currently popular in research and clinical psychology and claim to address shortcomings in "basic emotion" theory.

The Vector Model is another dimensional model that also relies on "valence" and "arousal" to define its axes. However, the key difference is in the structure of those axes. Where the Circumplex model is represented much like a cartesian coordinate system, the vector model has a singular origin at the neutral points of valence and arousal (here "intensity") (Bradley et al., 1992). The Vector model contends that high intensity emotions must be either extreme high or low on the valence axis, where low intensity emotions are close to neutrally valanced (see Figure 9) (Wilson et al., 2016). The exact precision and representativeness of the vector model over the circumplex model or other dimensional models is studied and debated, though generally authors are careful to note that certain models are situationally more correct and thus one universally representative model is not yet known.

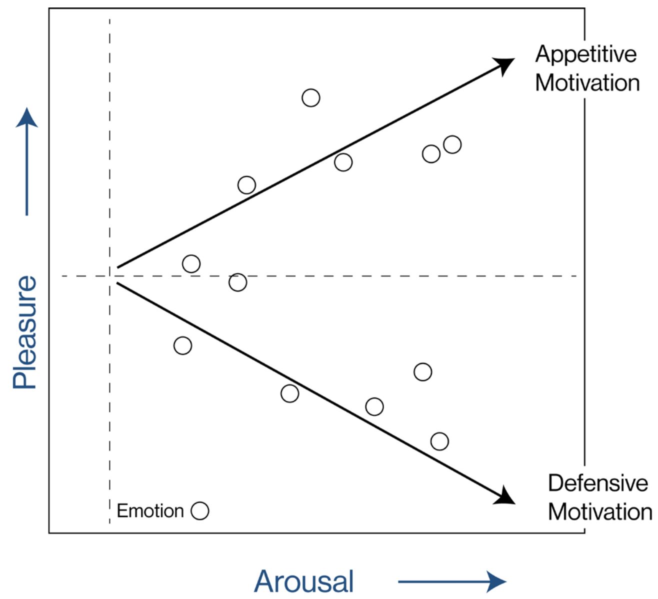


Figure 9. Vector Model, own image

These two models inform the desired design outcomes for this project through providing a direction by which we can seek to regulate affect through modulation of valence and arousal without specifically measuring and identifying discrete emotions (a functionally impossible task). We can identify target affective states

(such as "productive") and create design interventions to move people towards those states, but eliciting a specific emotion response in all contexts and scenarios is not feasible.

Boehner and colleagues propose exactly this viewpoint in their position on "emotion as interaction" (Boehner et al., 2007). To quote directly from their abstract, they suggest new goals for designed affective systems – "instead of sensing and transmitting emotion, systems should support human users in understanding, interpreting, and experiencing emotion in its full complexity and ambiguity" (Boehner et al., 2007, p. 275). This perspective ties in the loose focus on a 'somaesthetic outlook' on lived experience and our inclusion of embodied interaction principles later in the report.

These above approaches to studying, evaluating, and designing for affect all seek to understand and communicate what is an inherently complex topic. This graduation project leans in to the most cross-compatible and salient components of each theory and combines them to structure our philosophical outlook on emotion and affect-based design. As Boehner and colleagues eloquently state, "the way forward for affective computing and affective evaluation is not a debunking of objective approaches in total but a recognition of the limits and liabilities of both objective and subjective accounts of emotion" (Boehner et al., 2007, p. 289).

'Productive Mood State'

It is important to clarify exactly what is meant by a "productive" mood state, and what attributes we seek in achieving that state (Figure 10). Generally, a productive mood state is not compatible with pervasive anxiety and apprehension, as productivity requires performance, focus, and confidence. The mood typology (P. M. A. Desmet et al., 2020) characterizes mood through six categories of attributes: feeling, perception, reaction, tendency, liking, and disliking. The following is an abridged version of the mood typology entry for productive:

> Feeling: Sharp, focused, alert, and confident. One is calm yet energetic, ready for challenge.
> Perception: One is well-suited for the challenges ahead, with purpose, direction, and control.
> Reaction: Engrossed in activity, efficient and concise reactions.
> Tendency: Move with determination, upright posture, neutral expres-

sion, and clear voice.
Liking: Desire to solve problems, accomplish tasks, and do something meaningful.
Disliking: Wasting time, aimless and non-urgent activities, distraction.

Obviously, someone who is feeling productive is not required to experience all the above at once, or even ever. These are simply guiding descriptions of how a mood could be perceived. That said, it is a clear way by which we can set aims for our fidget object. We see in this description a lot of attributes that point to engagement and focus, as the willingness to accomplish challenging tasks is high and distraction is disliked. "Arousal" is not too high, as one is calm yet energetic and fully in control of themselves and the scenario around them. When referring to productive mood later in the report, these are the attributes being referenced.

2.1.2. Stress, Anxiety, and their Impact

We understand intuitively that too much stress or anxiety is correlated with negative outcomes in almost all domains of our lives. But what does science have to say on the topic? If we consider the vector model of emotion as explained above, high arousal emotions, and especially those that are negatively valenced, are seen to counterproductively influence our cognitive abilities.

Many studies are narrow in scope but can still provide generalizable knowledge. For example, people with "high math anxiety" exhibited "smaller working memory spans, especially when assessed with a computation-based span task." A reduction in working memory also is linked with increased reaction time and error rate in other application scenarios (Ashcraft & Kirk, 2001).

It would be outside the scope of this project to produce an exhaustive list of reasons why stress and anxiety are detrimental to overall wellbeing, but the above examples combined with the reader's own knowledge of their lived experience should serve as sufficient proof of fact. Regulation of one's affect thus is an important component of everyday life, whether regulated by external factors and parties or accomplished internally. The following section details relevant methods of affective self-regulation and contemporary design research in the field.

Affect (Self)Regulation

There exist many proposals for classifying the inherent affect regulation behavior that humans exhibit daily. Some are now outdated, and some are more "main-

Figure 10. Productive Mood State Typology Card. Xue and Desmet, 2020

stream." One of these theories that we leverage for this project is the Process Model of Emotion Regulation, first proposed by James Gross at the turn of the 21st century (Gross, 1998).

The process model, true to its name, posits that the experience of an emotion (and its regulation) is a process that contains many moments at which one can intervene to regulate that emotion. Gross gives sequential 5 categories: a) situation selection, b) situation modification, c) attentional deployment, d) cognitive change, and e) response modulation (Figure 11). Each of these categories can be further broken down into subcategories. For example, "reappraisal" is a subcategory of cognitive change, and is seen as particularly effective in decreasing negative emotional experience relative to other regulation attempts. Suppression, a form of response modulation, is seen to impair memory and decrease expression of an emotion, but not the felt experience of it (Gross, 2002, 2015). This model is applied to our second analytical research activity when classifying stress coping behaviors in a survey of university students. See Chapter 3.2 for outcomes of using this model.

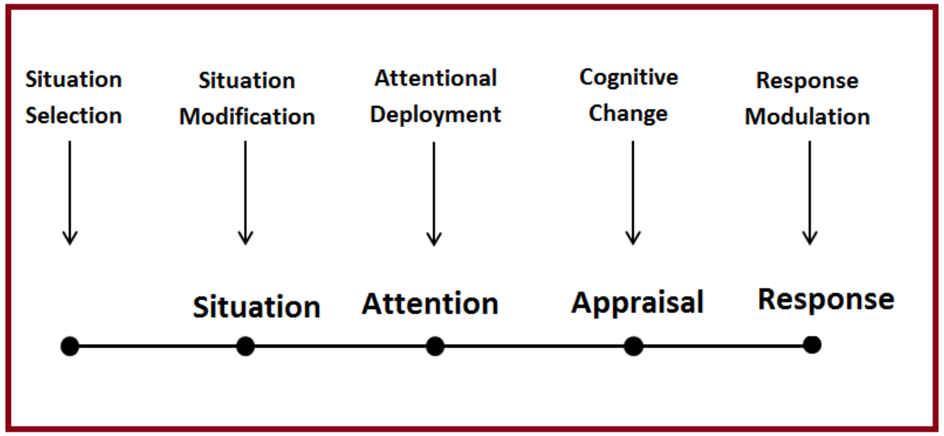


Figure 11. *Process Model Diagram. From Kstan*

Meditation

Meditation practices split a fine line between science and mysticism but are nonetheless a critical component of the affect regulation landscape. No matter the specific manifestation, most meditation practitioners seek to achieve a more "grounded," calm, attentive and aware state of being. Many practices may fall under the umbrella of "mindfulness" meditation, which is becoming increasingly popular in the western world. Classical meditation practices emerged from eastern religions before being modified and repurposed for non-secular contexts.

Specific touch-based meditation theory like the Relaxation Response theory is of interest to this project for its purported mechanism of heightening attention through slow, deliberate physical movement (Hussien Ahmed et al., 2017). Similar to the prior report section on the impact of stress and anxiety, we cannot possibly detail the full spectrum of meditation practices in this research, so we only discuss the most immediately relevant aspects.

The real challenge is determining whether meditation is useful in concrete measures. Anecdotal and some scientific evidence links meditation with reducing stress, anxiety, depression, and other affect disorders (Hölzel et al., 2011). Some studies however, are careful to qualify results and suggest more research is necessary drawing conclusions on the effectiveness of meditation therapies on affective disorders (Krisanaprakornkit et al., 2006). Additionally, meditation studies receive a fair bit of criticism for questionable research practices, samples sizes, and commercial interests of the authors. In one meta-analysis, "almost 75% of an initially identified 595 studies had to be excluded" due to methodological inconsistencies and failures (Sedlmeier et al., 2012). A second meta-analysis found "small to moderate reductions of multiple negative dimensions of psychological stress," but no more significant than clinical interventions (Goyal et al., 2014). Overall, the jury is still out on the exact power and efficacy of meditation as an intervention for stress, anxiety, and other affective mood issues.

Lastly, we wish to note that objective measures of whether meditation "helps" are perhaps not as important as individual perception of effect. Placebo effects are real and powerful, so the best path forward for this project is likely a multi-faceted one that makes appropriate use of clinical and meditational interventions when useful. As such, we do not position this graduation project (or meditation in general) as a panacea for negative affective states, but yet one more way in which we can support a transition towards personal wellbeing, especially in the pleasure and personal significance dimensions (Figure 12) as described by Desmet and Pohlmeyer (2013).

An interesting contrast is drawn between "mindful" and "mindless" behaviors in this project, and it is asked whether each could achieve the same effects when applied in different contexts and through different objects. Chapter 2.3 on Mind Wandering further investigates the overlap between these seemingly exclusive topics. Ultimately, we seek to integrate meditation practices in the utilization of our fidget object only to the degree that they serve our desired interaction outcomes. Our prototype will not be a “meditation aid” or “meditational anchor,” so to speak, but rather a product inspired by the goals and principles of meditation. The exact engagement with these principles is described in full in the prototype and concept development sections of this report (Chapter 4).

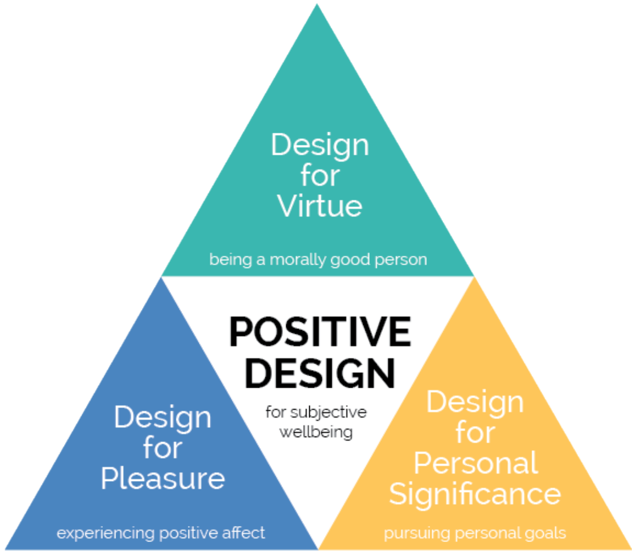


Figure 12. Positive Design Framework. Desmet and Pohlmeyer, 2013

Emotion, Affect, and Regulation Takeaways

While perhaps not fully representative of the depth of human emotion, basic models and typologies help to make designing for emotion accessible and understandable. We leverage Xue and Desmet’s typology of 20 moods to define the project goals around a “productive” mood state. A “vector” model of emotion is useful for characterizing ways in which affect could be modulated through design interventions, and the “process model” of self-regulation guides our later research to inform classifications of affect regulation behaviors. Boehner et al.’s “emotion as interaction” provides a clear link between embodied (and extended) object interaction and affect, further justifying the effects created through fidgeting behavior that are discussed later in theoretical research. We also seek to integrate the most advantageous elements of a mindfulness practice into the fidget object interactions we create, even as contrast is drawn between the different approaches of mindfulness and mindlessness. These theories in affect regulation require situating within the context of interaction, which can be found in the following sections.

2.2. Theories in (Interaction) Design

2.2.1. Embodied Interaction

> *“You cannot separate the individual from the world in which that individual lives and acts”*
> Paul Dourish, Where the Action Is: The Foundations of Embodied Interaction, p. 18

As a discipline, Human-Computer Interaction (HCI) is relatively new compared to established natural sciences. Since HCI is inextricably linked to the development of computing technology, it has seen increased focus and growth since the 1980s and has broadened to encompass so much more than our still-narrow definition of “personal computer.” One branch of philosophy and practice within HCI is termed “embodied interaction” and was effectively codified only 20 years ago (Dourish, 1999). Dourish described embodied interaction as drawing from the then-nascent concepts of “ubiquitous computing” and “social computing,” among others. As Dourish stated: “Embodied interaction is interaction with computer systems that occupy our world, a world of physical and social reality, and that exploit this fact in how they interact with us” (Dourish, 2001, p. 3).

Perhaps this description and the relevance to this project on affect regulation through tactile interaction is not immediately evident. The understanding of what is or is not a computer has also drastically shifted in recent years with the advent of widely available miniature, low power circuits. Everything from kids’ toys to kitchen tools is likely to contain some sort of processor and circuitry. One could easily extend the definition of “computer” to fit these items, even if we don’t interact with it via a keyboard and mouse (or touchscreen for the modern, mobile generation). If a device accepts input in some way (buttons, motion, sound), digitally processes it, and expresses a reaction, it can be considered as a computer. The role of HCI research in interaction design therefore becomes much clearer. Embodied interaction is then about our lived physical (corporeal) experience in the world and in interacting with computing technology. Embodied interaction researchers are interested in structuring theories and methods that can help us to systematically understand our modes of interaction and develop more “seamless” and appropriate ways of interfacing with technology. Current HCI thought believes an interaction is mediated entirely through bodily perception, and we cannot wholly separate rational thinking from the subjective experience of reality.

This mind-body unity is the biggest evolution to HCI thinking, as, in the past, designers and researchers treated the brain and body as two wholly separate systems. That dualism limited our ability to develop these “seamless” or “ubiquitous” computational objects and their presence in the world.

This graduation project deals in “haptics,” which describes information communication through the sense of touch, often through vibration and force-feedback systems (Figure 13). Haptics can be used for discrete information communication, but we see value in a more abstract aim for alerting someone to their own behaviors and feelings. Turning inward and conducting self-evaluation is a significant challenge for many, and in this project, the technology artifact operates as a vehicle to help one engage in self-understanding and internal dialogue. This differs from much embodied interaction research which focuses on the communication between two active and responsive parties: the human operator and the computing device.

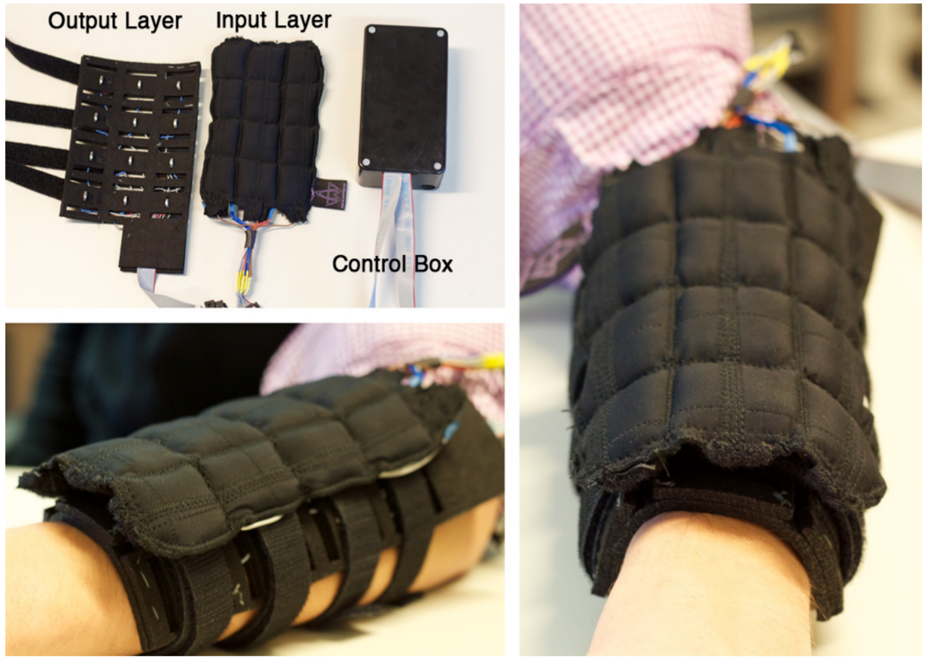


Figure 13. Haptic “Tactile Sleeve for Social Touch.” Huisman et al., 2013

Embodied Interaction is the overarching domain that has allowed for many of the following theoretical concepts to develop and find footing. Therefore, the following theories must be situated within our current knowledge in embodied interaction and design.

2.2.2. Affective Loops

An Affective Loop Experience is a product interaction that is physically embodied and concerns interactive affective systems (Höök, 2008). It specifically allows for users to actively decide their level of engagement with the interaction. At the core, the interaction is simple: a user expresses their emotion (affective state) through a tangible product interaction. That activates some type of expressive response from the system, which triggers an embodied response from the user (and the loop continues). Figure 14 visualizes this process and is reused from Bruns Alonso’s PhD thesis (2013). This construction describes interactions that are not trying to measure and interpret a person’s emotional state, but rather involve users in a tangible and emotional experience.

The affective loop strong concept was evolved by the original authors through experimentation, and settles on proposing the following positions which are relevant for this graduation project:

> 1) Emotions are seen as processes constructed in the interaction and starting from experiences.
> 2) The user is an active, meaning-making individual. Interpretation responsibility does not lie with the system/product.
> 3) Affective loops help avoid body-mind dualism and a reductionist interpretation of experience. (Höök, 2008, p.8)

The affective loop concept creates a clear link between interaction design theory and somaesthetic theory for use in affective experiences. We allow ourselves to remove the burden of “proof” or interpretation of an emotion state and to view it holistically, without reducing that experience to an inadequate set of simplified labels and descriptors. Through framing this project’s desired interaction as a type of affective loop, we link different philosophical and practical perspectives on affect regulation and clearly define the desired outcomes for the tangible product interaction. However, we reformulate the affective loop through the concept of “unaware interaction.”

2.2.3. Unaware Interaction

Of relevance to this project is a proposed modification to the “affective loop” concept that originated within the PhD thesis work of Miguel Bruns Alonso. His work sought to influence emotional response through tactile interaction with a daily object, in his case specifically, a pen (Bruns Alonso, 2010). The pen was embodied so it could sense restlessness through interaction and then provide “inherent feedback” to the user to draw attention to and influence the experience and perception of emotions. The thesis and a follow-up publication demonstrated his interaction concept which he named “unaware interaction” (Bruns Alonso et al., 2013).

In the context of product interaction, “inherent feedback” deals with our interaction with a product, specifically physical movement. Inherent feedback is the information given to a user in response to their input action, for example the noise and tactile sensation of a button pushed on a television remote (Wensveen et al., 2004). Bruns Alonso et al. (2013) present inherent feedback as a prerequisite and launching point for unaware interaction. Following from Wensveen et al.’s work, Bruns Alonso sees inherent feedback as also shifting into “feed-forward” and influencing user actions to create a feedback loop. All that’s left is to add “emotion” into the experience of the product and one has created an affective feedback loop that can influence a user’s emotions.

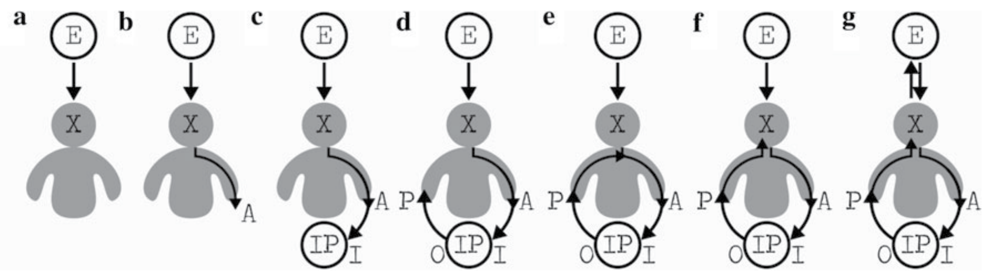


Figure 14. Affective Loop Process. Bruns Alonso et al., 2013
E - Emotional Event; X - Emotional Experience; A - Action; I - Input
IP - Interactive Product; O - Output; P - Perception

Bruns Alonso then proposes a framework for creating an affective feedback loop stemming from interaction with a product. His conclusion, after testing his Relax! pen prototype, was twofold: first, inherent feedback was not a statistically significant behavioral modifier, though the potential existed as qualitative evaluators showed promise. Second, he proposed the “unaware interaction” concept as an explanation for the study results.

When the product user is unaware of their own (unconscious) interaction and is also unaware of the product actively responding, they effectively skip the step of cognitively experiencing an emotional event. As every element of the interaction is mediated through the body, the body itself responds to changes in product feedback and behavior without involving cognitive perception (Figure 15). This is the foundational basis of an “unaware interaction” concept. The distinction between an “unaware” and “unconscious” interaction is very slight and worth clarifying: “Unaware” is a subgroup of unconscious interactions and refers to the (lack of) user’s perception of the effects and intervention created by the object in question. Unconscious interaction refers to the larger pattern of use, where a user is not even cognizant of the fact they are interacting or chose to interact with a specific object.

It is worth mentioning the rather large limitations of this study in sample size and results power, but the theoretical proposal is still interesting in the context of this graduation project. There exists an opportunity to create an interaction that shifts between awareness levels, becoming an affective loop when consciously known and an unaware interaction when inherent and unknown. By inhabiting both levels of awareness, such an interaction can selectively influence affect and capture a user’s attention only when necessary. Importantly, that interaction must exist within an “implicit” structure, explained in the following section.

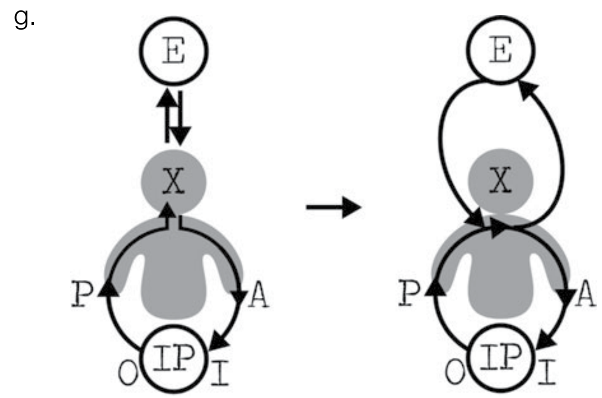


Figure 15. “Unaware Interaction” Modifier. Bruns Alonso et al., 2013
Figure Shows a ‘Skip’ of the Cognitive Processing of an Emotion.

2.2.4. Implicit and Explicit Interaction

To add yet more definitions to this complicated soup of terminology, it is important to clarify the meaning of implicit and explicit interactions, as well as their relation to “unconscious” interactions. Understanding these terms helps to explain the difference between affective loop experiences and unaware interaction as well. As expected, many different definitions of implicit interaction exist, and they are almost always coupled with their opposite, “explicit interaction.” Serim and Jacucci categorize implicit interaction as five different keywords based on literature review of the terms’ use in academia. Implicit interaction can be seen as unintentional, attentional background, unaware, unconscious, and implicature (Serim & Jacucci, 2019). Rather than explicate all of these, we select the most relevant definitions for this project.

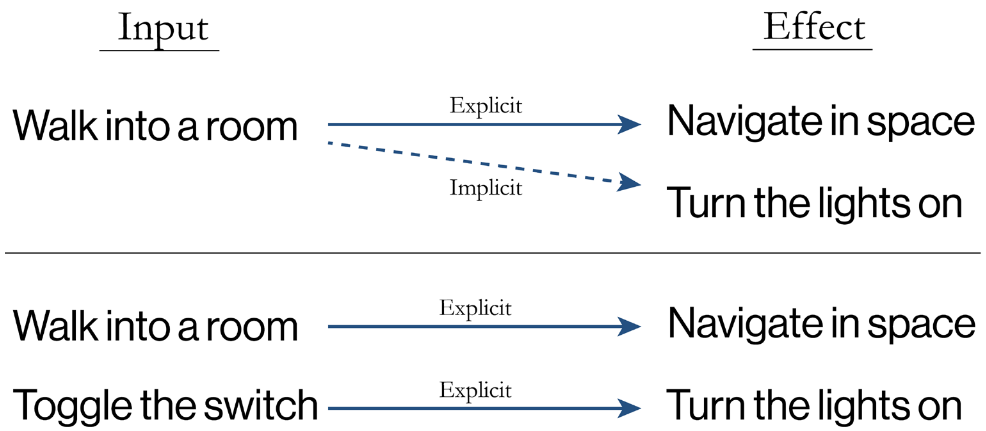


Figure 16. Input and Effect Pairings to Explain the Difference Between Implicit and Explicit Interactions

One selected and relevant definition of implicit interaction is “an action performed by the user that is not aimed to interact with a computerized system but which such a system understands as input” (Schmidt, 2000). For our future technologically enabled fidget object, this definition makes sense and fits somewhere within Serim & Jacucci’s unintentional and unaware categories. Explicit interaction is therefore also defined specifically as an interaction between a user and computational device where the user intends to generate an input of some form (with expectation of a correlated system output).

In creating their own definition, Serim and Jacucci focus on intentionality, and consider an aggregate definition to thus be “interactions in which the appropriateness of a system response to the user input (i.e., an effect) does not rely on the user having conducted the input to it” (Serim & Jacucci, 2019, p.8-9). We accept this definition and translate it into more relevant and actionable terms for this project. A fidget object that exhibits implicit interaction therefore produces specific effects due to the way a user interacts with the object. However, those effects are perceptually decoupled for the user, and their manifestation of fidgeting has no intent of generating feedback.

An ”unconscious” interaction can be seen as similar to implicit, but on a higher level of abstraction. Fidgeting is unconscious when the user is manipulating a fidget object without awareness of their bodily movements or perhaps even that they are holding and using an object. An unconscious interaction therefore requires the interaction to also be implicit, as explicit suggests intentions and awareness. With this project, we wish to design and implement a fidget object that can shift a user between a conscious and unconscious use state. When fidgeting is too severe, or exhibits other markers of anxiety, stress, or inattention, the device provides feedback that draws awareness to itself. Through this awareness, the interaction becomes conscious. Even still, the interaction is implicit as the user has no intent of generating that specific feedback and may not even know how to generate it. Thus, unconscious interactions must be implicit, but conscious interactions do not require explicit interaction.

Conclusion

This exploration of interaction design principles was not only helpful but also necessary for conducting this graduation project. We highlight the project position within embodied interaction, and our goal of producing an interaction which is implicit, while also shifting between states of awareness to create specific effects for a user. Much of the remaining analysis and design work stems directly from the more philosophical positions established in this chapter. We use this theoretical base to establish aims for our design concepts and to construct later theories around fidgeting. The following takeaways highlight some of the most critical points from each preceding section, though it is far from an exhaustive list.

2

Interaction Design Takeaways

Embodied Interaction:

- *Embodied interaction research creates theories and methods to help us systematically understand our modes of interaction and develop more "seamless" and appropriate ways of interfacing with (embedded) technology.*
- *As we experience the world corporeally, embodied interaction principles will be leverage is designing systems that aid us in "turning inwards" with reflective behavior.*

Affective Loops:

- *Through framing this project's desired interaction as an affective loop, we link different philosophical and practical perspectives on affect regulation and accept a holistic and non-reductive stance on designing for emotion.*

Unaware Interaction:

- *Unaware interaction is a modification of the "Affective Loop" strong concept that essentially "skips" the cognitive processing step of an emotional influence*
- *Using "inherent" and implicit feedback, an unaware interaction influences one's affective state through physio-motor intervention on an unconscious level.*

Implicit Interaction:

- *Unconscious interactions must be implicit, but conscious interactions do not require explicit interaction. We aim to create an implicit interaction that moves between unconscious and conscious levels.*

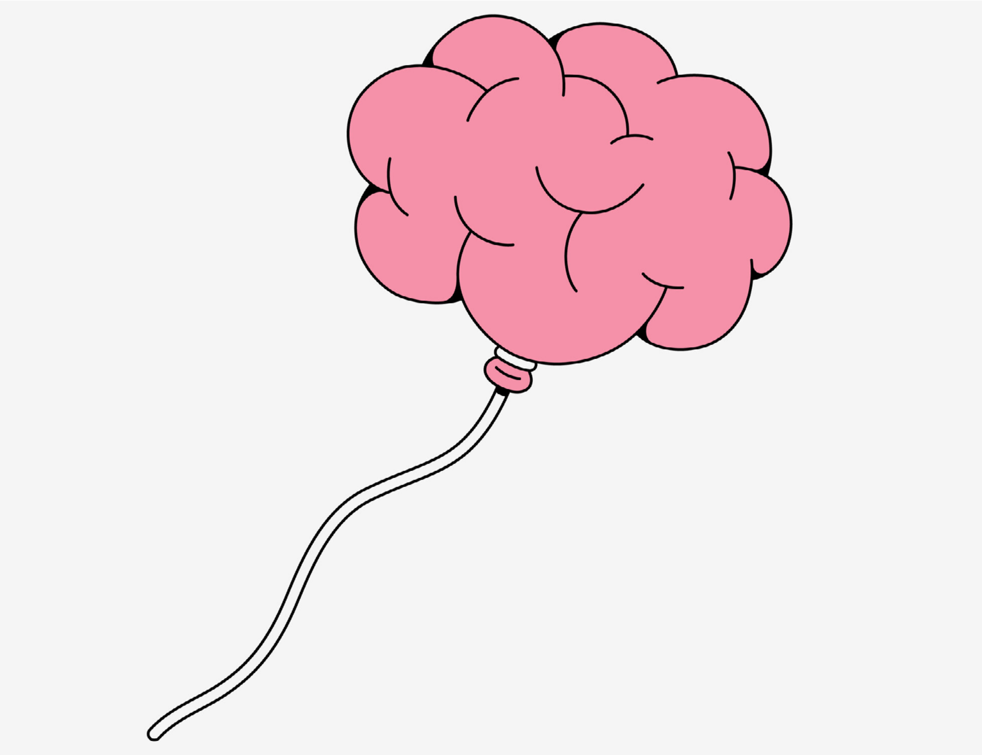


Figure 17. Artist Impression of "Mind Wandering." RaDIo for NYTimes

2.3. Mind Wandering

The study of mind wandering is an in-vogue topic in academic literature at present, with research originating in overlapping fields such as design, neuroscience, child development, and more. One paper was written on the topic in 2006, while 132 or more were published in 2018 (Seli, 2019). Effectively, "mind wandering" is an umbrella term for the experience of one's thoughts deviating, seemingly in random directions, from the task at hand. Some authors suggest mind wandering could occupy up to 50% of humans' waking thoughts, though studies in response to these claims reveal a non-binary "disengagement" from tasks, suggesting differentiable levels of intensity to these wind wandering episodes (Seli et al., 2018). This wandering is especially prevalent when the task at hand requires singularly focused attention, or when a task is so common as to become automatic (such as brushing one's teeth or driving a morning commute). The terms "train of thought" and "stream of consciousness" have long been used in popular lexicon to describe this exact phenomenon. Attributed to William James, these visual metaphors helped us to understand and conceptualized our cognitive processes in an era before detailed computer imaging (James, 1890).

There are contemporary scientific perspectives and theories, such as the discovery of a Default Mode Network (DMN), that help to develop models of mind wandering and to understand potential correlations with other cognitive processes. That said, what matters most to this project is how mind wandering relates to fidgeting and can be leveraged in pursuit of a productive mood state.

2.3.1. Mindfulness vs Mindlessness vs Mind Wandering

In discussing mind wandering, related terms are often introduced without proper definition or clarity. For the sake of precise argumentation, we will define mindfulness, mindlessness, and mind wandering here:

> Mindful(ness) – 1. the quality or state of being conscious or aware of something. 2. A mental state achieved by focusing one's awareness on the present moment, while calmly acknowledging and accepting one's feelings, thoughts, and bodily sensations.
> Mindless(ness) – 1. (of an activity) so simple or repetitive as to be performed automatically. 2. Acting or done without justification and with no concern for the consequences
> Mind wandering – 1. conceptualized as 'attentionally unguided thought.' 2. Inability for thoughts to stay on a single topic over a period of time, especially during an attention-demanding task.

These three definitions (from the Oxford English Dictionary, with adaptations) hold for the following sections and the remainder of this project report. Some authors position mindfulness and mind wandering as diametric opposites (Mrazek et al., 2012) and believe that mindfulness training can reduce the frequency and duration of mind wandering episodes. These definitions do not exclude such perspective, and in fact fit well in constructing mindfulness and mind wandering as opposite states of being.

2.3.2. Value and Effect on Affect

Current research takes a largely negative view on mind wandering, especially an unintentional or "spontaneous" kind. This research details its effects on reducing working memory capacity, recall and retention, reading comprehension, and more. Spontaneous mind wandering behaviors are also more prevalent in those

with ADHD (Seli et al., 2015) and more frequent in people with a pervasive negative affective state (Smallwood et al., 2009).

Despite the uniform opinion that (unintentional) mind wandering lowers critical abilities in attention and memory, some positive outcomes are acknowledged. Mind wandering, especially when intentionally pursued, is a powerful tool for creative ideation and exploration (Baird et al., 2012). It allows for introspective reflection on self and on others around oneself, as well as the time to make abstract connections and thoughts. It is clear that we cannot universally declare mind wandering a 'good' or 'bad,' but rather should seek to selectively enable the most beneficial elements.

In this batch of literature research, the author seeks to position fidgeting within the complex space of mind wandering: is it beneficial for eliminating mind wandering? Or does it generate mind-wandering behavior? Can fidgeting modulate and constrain mind wandering to a practically useful application?

As mentioned briefly above, research has demonstrated a correlation (though not necessarily causation) between mind wandering and affective state. Smallwood (Smallwood et al., 2009) summarizes that "task-unrelated thoughts" (TUTs) are more frequent in those with low mood states. As we know that mind wandering activates the DMN, the activity of said network has a potential affective impact. Concerns over the future that emerge during episodes of mind wandering can impact a present affective state, and even perhaps contribute to a cyclical building and maintaining of a negative affective state (Stawarczyk et al., 2013).

Many people have also been conditioned throughout their youth that distraction and mind wandering and undesirable traits, and thus, upon recognition of such an action, feel negative about themselves and their abilities of self-control. In reality, mind wandering is wholly natural, but social expectations and norms likely have an affective impact all the same.

2.3.3. Extended Mind Wandering

Returning to the concept of embodied interaction, one of the core theoretical foundations of this project, we now can extend that theory even further. A specific subset of embodied cognition called "extended mind thesis" (EMT) has become relevant in the mind wandering space. Depending on interpretation, the EMT or "extended cognition" proposes that the objects and environments that one interacts with are part of a larger, distributed cognitive system. Some scholars assert that cognition thus take place inside these external resources themselves, but this interpretation digs too deep into phenomenology for use in this project. These definitions and interpretations of extended cognition all originate in a detailed writeup of embodied cognition and it's variants by Lawrence Shapiro and Shannon Spaulding (2021).

Authors Jelle Bruineberg and Regina E. Fabry (Bruineberg & Fabry, 2021) propose a framework of "extended mind wandering" in their research of modern smartphone usage associated with primary focus tasks. This framework links extended cognition with mind wandering to categorize mind wandering that is enacted through an external computational object. The authors specify an ICT device in their instance, but we presume a less connected but interactive device could also exist under the same framework. This framework proposes a few key differentiations we wish to highlight.

First, the authors utilize a definition from Hiniker et al. (Hiniker et al., 2016) to draw a distinction between ritualistic and instrumental use of the ICT device, where the former is "habitual and diversionary" and the latter is "goal directed and purposeful." They use this distinction in building a claim that ritualistic smartphone use during a primary task is a clear case of extended mind wandering. They also leverage a definition of mind wandering as "an absence of attentional guidance," which emphasizes the latent ability of a person to focus attention on relevant items, but the lack of support to enable them to do so (Bruineberg & Fabry, 2021). Thus, an outside object or resource is part of mind wandering episode that is both extended through that object and develops over time (non-instantaneous).

Figure 18. Example of Ritualistic (L) and Instrumental (R) Use of a Pen.

The authors create a framework (Figure 19) with which to define extended mind wandering, and determine it has the following characteristics: first it is perceptually coupled, meaning the mind wandering has some stimulus and interaction with an ICT device. Next, extended mind wandering is unguided and either unrelated to the task at hand or fully free from any task. Lastly, the authors suggest that episodes of extended mind wandering can float between being intentional and unintentional, as well as being meta-aware and meta-unaware at different moments. The "perceptual coupling" challenges pervasive accepted definitions of mind wandering as a stimulus-independent process that is "perceptually decoupled." Specifically, the perceptual coupling originates from the fact that this "extended" for of mind wandering requires some external object as part of the system.

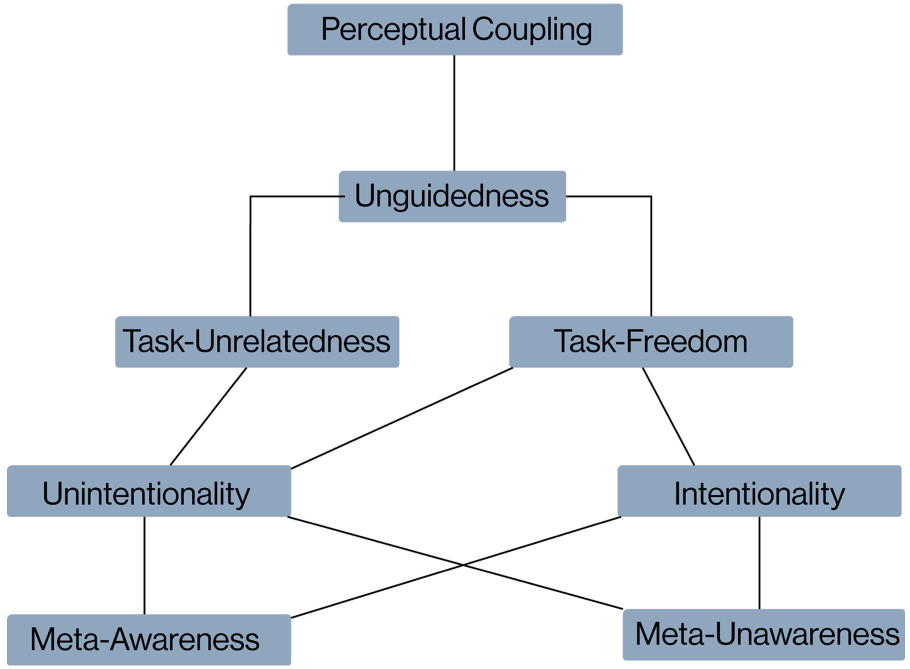


Figure 19. Extended Mind Wandering Framework (Adapted)

These proposed attributes of extended mind wandering can be of benefit as we seek to position a fidgeting object as an unaware interaction that produces beneficial affective change. The terms "intentional" and "unintentional" should also recall the section 2.2.4 on implicit interaction its definition in terms of intentionality. We can clearly see that extended mind wandering can take place as an implicit interaction, and even vary between levels of awareness.

One point of disagreement is on the mutual exclusivity of ritualistic and instrumental extended mind wandering. It is a core proposal of this project that ritualistic and unconscious fidgeting behavior is not purely diversionary, but rather contains elements of purpose and perhaps even an (unconscious) goal. People who fidget do so for a variety of reasons (see Chapter 3 and 4), but a reason does exist. The following section will explain how we adapt extended mind wandering to this project and propound that the "ritualistic" form can be leveraged in a positive way when bounded by a fidgeting object.

2.4. Reflexive Focus Bounding

Through the complete body of research outcomes (in the preceding sections and from later research activities), we construct a theory to describe a potential mechanism by which fidgeting can aid in attentional focus and regulating affective state. One common use for fidgeting is to augment creative ideation, and this is often done with a more free-form, generative fidget object. In this use, mind wandering is encouraged and potentially necessary, and an open-ended, interpretative fidget object can encourage mind wandering. The second main use is to regulate attention, focus, and engagement. While many researchers connect fidgeting with distraction and inattention, some believe "object-mediated micro fidgeting increases energy expenditure and bodily arousal to maintain focus and attention," and therefore reduces mind wandering (Farley et al., 2013). This is directly linked to the vector model, regulating the arousal dimension to modify affective state. We propose a third theory, "Reflexive Focus Bounding" (RFB), which positions fidget objects as exemplars of extended mind wandering that constrain the limits of one's mind wandering and enable a quicker and easier return to a focused and on-task cognitive state.

Current literature does not adequately address the diversity of fidgeting behavior and does not operate from clear or consensus definitions of fidgeting. For this project, fidgeting is seen as a repetitious and ritualistic sensorimotor interaction, primarily with one's hands and thus on a "micro" scale. Much literature looks at "macro" whole body movements like leg bouncing, stretching, and other large-scale motions, sometimes in combination with micro fidgeting. For example, one of Paul Seli's studies defined measurable fidgeting as "the total amount movement detected via the Wii Balance Board," with a participant sitting on an intelligent balance (Seli et al., 2014, p. 662). Logically, this will only capture macro,

whole-body type movements with any discernable precision. Another study (Farley et al., 2013) tracked fidgeting in both 'macro' and 'micro' categories over the course of a video lecture, and found decreased attention as a function of time alongside an increase in macro fidgeting with no statistically significant increase in micro fidgeting. As the author states, these results "provide tentative evidence for the existence of dissociable 'types' of fidgeting. This possibility opens a potentially important line of inquiry for future investigation" (Farley et al., 2013, p. 6). It is within these dissociable types that we propose the theory of Reflexive Focus Bounding.

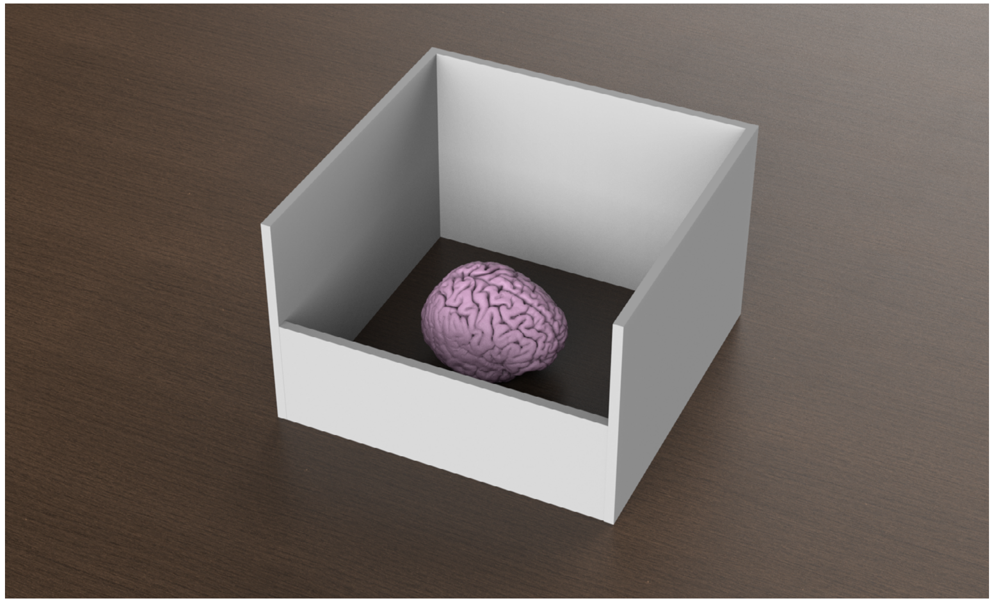


Figure 20. "Building Walls around a Wandering Mind, own image

We take inspiration from the concept of an "attentional anchor," or a real or imagined construction that serves to constrain one's interaction with their environment. Attentional anchors are used in traditional meditation practices (such as prayer beads or even one's breathing) as well as in complex everyday tasks like mathematics (Duijzer et al., 2017). Primarily, an attentional anchor allows for a simple, known "default" thing on which to center one's thoughts. We believe that micro-scale, object-mediated fidgeting behaviors can act as attentional anchors for daily work-related tasks and are used with the intent of Reflexive Focus Bounding. Reflexive Focus Bounding hypothesizes that a fidget object is an extended cognitive artifact that puts limits on what we are thinking about and our distraction from a primary task. It metaphorically "builds walls" around one's wandering mind, allowing it only to wander within the small, known space of tangible interaction with

2

that object. Fidgeting that would otherwise contribute to episodes of spontaneous (and uncontrolled) mind wandering is captured and redirected by and through the fidgeting object. Thus, a fidget object can clearly act as an exemplar of extended mind wandering, even if less complex than the ICT devices of Bruineberg and Fabry (2021).

What is key is the repetitive, automatic, and simple nature of the interaction. Fidgeting of this type challenges the definitions of ritualistic and instrumental ICT device use from Hiniker (as used by Bruineberg and Fabry); object-mediated micro fidgeting is habitual but not fully diversionary and can be purposeful without itself having an explicit goal. As such it contains elements of both terms definitions and is a unique type of interaction. Fidgeting has already been seen to bridge the implicit/explicit interaction divide, and here again it challenges existing structures of motivation for object engagement.

As authors in mind wandering research have suggested, “the benefits of a straightforward and simple activity to reduce mind-wandering has great practical significance” (Mrazek et al., 2012). We find object-mediated, micro-scale fidgeting to be a clear fit for this proposed activity, especially if using an intelligent or responsive object. Therefore, we seek to later define the characteristics of the extended mind wandering interaction needed to fulfill this role and provide an effective experience in affect and focus/productivity regulation. The conducted user studies, specifically theme 6 of the Reflexive Thematic Analysis, and prototype test lend support to the RFB theory and help to inform these interaction characteristics.

Mind Wandering Takeaways

Mind wandering is largely harmful to attention, memory, learning, and recall, though intentional mind wandering can be an important component of creative ideation and self-reflective thought. Research has demonstrated a correlation (though not necessarily causation) between mind wandering and negative affective states. Mindfulness, mindlessness, and mind wandering all have interrelation, and mindfulness and mind wandering can be seen as almost diametric opposites. EMT or “extended cognition” proposes that the objects and environments that one interacts with are part of a larger, distributed cognitive system. This can be melded with mind wandering as “extended mind wandering,” especially when applied to a computational object. Authors currently view extended mind wandering as similar to standard mind wandering in its causes and effects.

We find research on fidgeting and mind wandering it does not properly address fidgeting behaviors as manifested in real-world scenarios. A large portion of this poor fit can be seen as resulting from vague and variable definitions of fidgeting itself and the inclusion of macro-scale “discomfort-presenting” fidgeting. We propose Reflexive Focus Bounding (RFB), a theory of fidget objects as extended cognitive artifacts that place limits on the extent of our mind wandering and our distraction from a primary task. RFB challenges the distinction between ritualistic and instrumental classifications of smart devices and proposes a novel interaction that bridges the two. We identify an opportunity to construct a fidgeting interaction that is dynamic, personal, and “smart” in communication with a person and their bodily expressions of affect.

2.5. Technology Research

Connection to Technology

All of the prior theoretical topics are derived from purely academic knowledge and will shape the direction and outcomes of this graduation project. One area in which they are relevant is in the application of technology to the “smart” fidget object we will develop. In order to construct a functional prototype, or even to understand where to begin, it is critical to understand the contemporary landscape of available products in affect regulation and recording. Many products in these spaces exist in different use contexts and scale, but still, their methodology and embodiment will be informative for this project. The follow sections detail some further theory in using technology in accordance with the aims of this project, as well as some example products from research or market.

A significant portion of the early theoretical research centered around technology and implementations of “feedback” in existing devices that purport to influence and impact affective state. Specifically, we were interested in biofeedback, or feedback that is directly related to sensed biological information such as heart rate variability (HRV) or other measures. We also investigated current implementations of “responsive” technology that changes form based on user input and perception of different feedback modalities. In the interest of brevity, we will only share findings that had a significant impact on the course of this project and decisions made over time. Much of our findings in this space informed what the concept “could not” be, rather than what was possible.

Biofeedback and Biosensing

When it comes to measuring or sensing emotion of a person, there is no foolproof method. Emotions are in some ways unique for everybody, so generalized classification and detection are challenging. However, certain methods have been determined to be effective. Importantly, biosensing is not always a “first choice” method of identifying affect. Facial expressions, speech, and body movements and gestures are three very common modes of expression (Pal et al., 2021). For measuring biological data, the following are common choices:

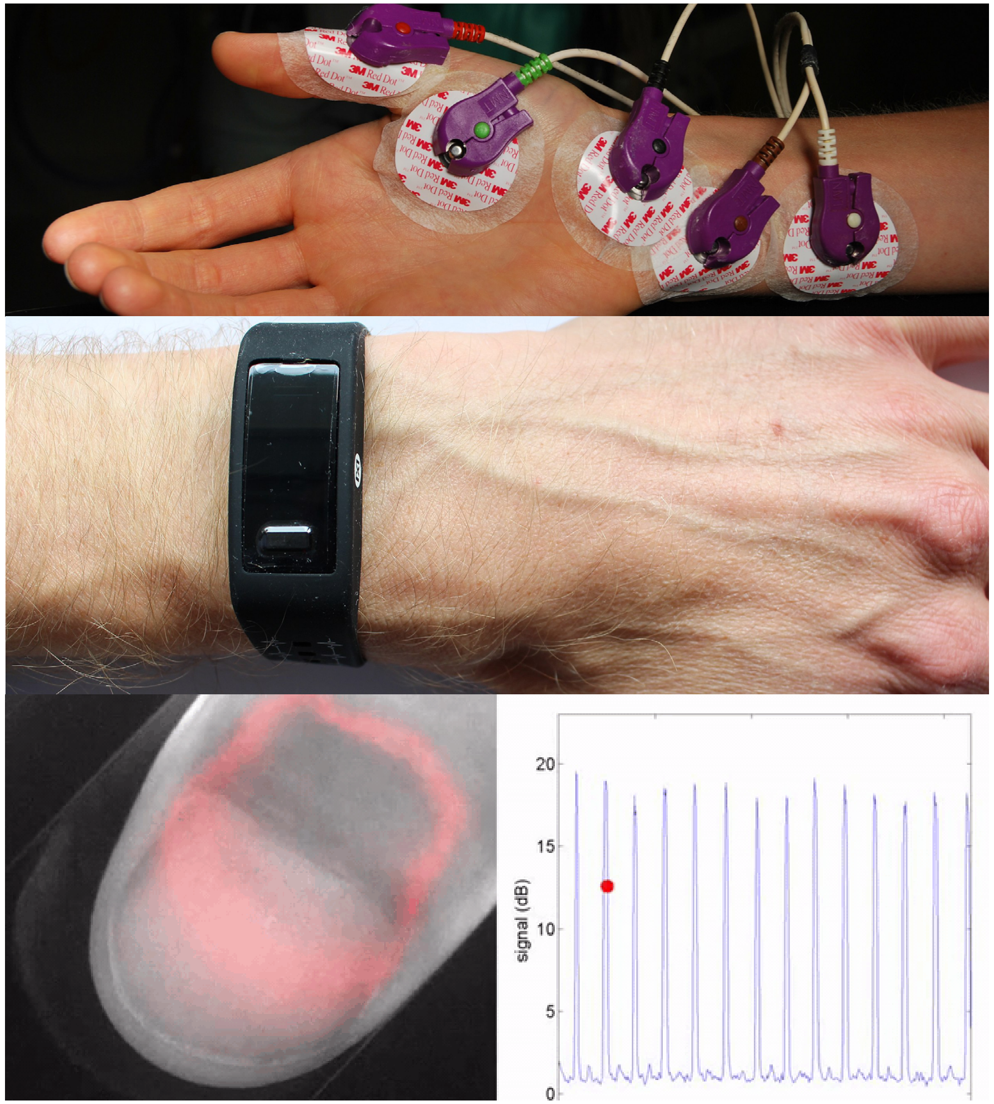


Figure 21. Composite Visual for Biosensing Technologies. Top: EMG, Middle: PPG Wristband, Bottom: Laser Doppler Imaging of BVP of Thumb

- PPG (photoplethysmography) used to determine blood volume pulse (BVP) and heart rate variability (HRV).
- For instance, electromyography (EMG), which refers to the muscle activity which can also be seen through galvanic skin response (GSR)
- Skin temperature.
- Respiration (depth and speed)
- Electroencephalography (EEG) for brainwave measuring, done pads on head.
- Electrooculography (EOG) for eye movements with sensors on skin.
- Electrocardiography (ECG) for electrical signals from heart.

Findings indicate that stress (more accurately arousal) can be measured from detecting heart rate variability (HRV), and which is a measure of the variation of the inter-beat interval between heart beats (Liang et al., 2018). A higher HRV shows more resilience against changing scenarios and a lower state of negatively valenced arousal (Pal et al., 2021). GSR is also a common indicator and is used in conjunction with HRV in numerous products, including the Apollo Neuro (Siegle & Rabin, 2019).

It is worth noting the difficult of achieving stable and accurate biological measurements over time, especially outside of a laboratory context. Physical movement is often enough to misalign sensor data, and not every area of the human body is sufficiently capable of providing adequate data. This is part of why so many current market products are wrist- or chest-mounted wearable devices (Umair, Chalabianloo, et al., 2021). In this project, we eschew biosensing for other forms of measurable data, mostly to avoid having to wear the product and for the technological difficulties of stable measurement.

Responsive Technologies

Feedback is a “responsive” technology as it signifies some change in state and responds to that change in a detectable way. That said, there are varying degrees of responsiveness and link to human action. Some feedback stems from clear action (e.g., a metal baseball bat making a “pling” sounds when hitting a ball) where other feedback is originated by more subtle state change. For this project, we are interested in feedback that originates without conscious action or intervention by the user, feedback that is derived from an “implicit” interaction.

Some great examples come from somaesthetic interaction design, specifically the “breathing wings” speculative design project and “Breathing Shell” artifact (Tsaknaki, 2021; Tsaknaki et al., 2021). Both projects leverage our breath and breathing patterns as the “input” to the system, which responds in kind through inflatable pillows to exert subtle pressure on the body (Figure 22). In this interaction, one is not intentionally acting to seek feedback, the feedback emerges from this implicit interaction which just so happens to take place while breathing. Thus, the authors have created a responsive technology that engages in a feedback dialogue of sorts, without extra effort on behalf of the user. This interaction is personal, subtle, and inspirational for our project aims.

Figure 22. Breathing Shell and Wings Prototypes. Tsaknaki et al., 2021

This sort of corporeal feedback can also be used in a more structured and persuasive manner. One study found that real-time feedback of heart rate or breathing rate did not help participants to become less anxious, and therefore challenges the idea that representation of one’s internal state is helpful for affect regulation (Costa et al., 2016). The same study found that “false feedback,” when represented as real bio-sensed data, could help participants modulate heart rate and breathing towards the value represented in the data and feedback. This matching of bodily rhythm to feedback is termed “rhythmic entrainment” and is yet another mechanism by which we could influence an individual’s affect (Umair, Sas, et al., 2021). This is all to say that just feedback might not enable desired regulatory effects just because feedback accurately represents some internal state of being.

Feedback Modalities

Perhaps most important is the mode in which feedback is delivered. If feedback type itself (e.g., vibration) elicits a specific emotional or physical response, then it

may not be suitable for our use context. By the same logic, feedback modalities could be quite useful for their embodied emotional content as well! We investigated whether there exist any of these latent perceptions of common feedback mechanisms so that we can most appropriately apply them to the project.

Generally speaking, most feedback modalities were seen as emotionally neutral; however, their implementations most definitely exhibited affective impact. Results from a quantitative study on the differences between thermal and vibration feedback and their impact on stress and anxiety suggest that cool temperatures and low frequency vibrations can produce the largest positive regulation effects (Umair, Sas, et al., 2021).

Generally, auditory and visual feedback are perceived as more external and distracting than vibration. Feedback that places “too much emphasis on explorations outside your own body, such as 3D sound or visualizations” are too distracting for a subtle, implicit interactions (Höök et al., 2016). That feedback can most definitely create emotional impact, but perhaps not in the frameworks in which we wish to operate.

Temperature (heat and cool) is a frequent subject of the work of somaesthetic interaction designers, as they perceive it as more human and “internally originated” than vibration feedback, which can feel foreign and external (Jonsson et al., 2016; Ståhl et al., 2016). Heat can be readily linked to states of arousal, not only to share that information externally, but also to initiate interactions to soothe users (Alfaras et al., 2020). That said, some authors give contradictory opinions, for example that vibration could be seen as intimate because it is local and only perceivable by someone in contact with the device (Schiphorst, 2009). Regardless, we can acknowledge the untapped potential of designing temperature change as a feedback modality in affective design (Alfaras et al., 2020; Umair, Sas, et al., 2021).

Takeaways

Much of the exploration of the exact effects of different feedback modalities (and even specific implementations of each modality) has been excluded for this report. While useful for understanding what has already been created or studied, most of the information exists at a very granular level of abstraction and is only situationally relevant. Broad conclusions were few and far between. Therefore, the following points represent the main conclusions that influence prototype development.

- *Biosensing, especially of heart rate variability (HRV) and galvanic skin response (GSR) can be instrumental in detecting states of arousal, and some amount of valence.*
- *It is difficult to get reliable and continued bio-sensed data in real-world environments.*
- *We eschew biosensing due to technological difficulties and the constraints it sets for project embodiment.*
- *Responsive technology varies in its interactional "explicitness," and we aim for the implicit types.*
- *Heat as a feedback modality has lots of potential, is often seen as generate inside the body*
- *Vibration feedback receives much attention in literature, opinions are mixed on its perception.*
- *Real-time representations of one's internal state are not always useful in affect regulation.*

2

2.6. Conclusions

This literature review was a central focus for this graduation project, occupying approximately the first 45% of the time allotted (plus more time sporadically at later moments). One of the main value propositions of this project is defining the landscape of fidgeting as it is situated within contemporary interaction and experience design research and practice. We also developed "Reflexive Focus Bounding" from the knowledge synthesized in this portion of the project. We expect the results of this project to provide a foundational basis for future exploration of fidgeting behaviors and design interventions to leverage fidgeting as an affect regulation tool. Literature research gave us knowledge to effectively analyze data sets and conduct analyses to scope our project and prototyping. Within prototyping, we also gained a head start on understanding what materials (physical and digital) useful, and which types of interaction should be reproduced with a fidgeting device.

Rather than repeat an exhaustive summary of the chapter here, please see the "takeaways" paragraph of each section for the conclusions drawn in each thematic area. Many of these points will return later as motivation and justification in

applied research and prototyping.
It was at this stage that we reformulated our original research questions to take better account of the new knowledge gained in these subject areas. One can see the original and reformulated questions in Chapter 1.2. They continue to guide the overall structure of our research and will be answered by the conclusion of this project and report.

With a solid theoretical foundation in fidgeting, affect regulation, interaction principles, and many other topics, we sought to apply our knowledge in research activities that analyzed real-world data. The following chapter details these efforts and the conclusions reached, as well as how they influenced later concept development.

3. “Active” Research Studies

3

Introduction

The structure of this graduation project placed heavy emphasis on explorative academic research, synthesizing insights from diverse fields to produce an understanding of fidgeting from a design perspective. Such knowledge, however, needs to be actively studied and validated to demonstrate correlation in the real world and utility for other contexts. In the following sections, the author details three distinct studies that apply theoretical knowledge from the prior chapters at different scales: first, an intimate three-person autoethnographic and self-observational study by three researchers; second, an evaluation of a dataset on common stress causes from a fellow master’s degree candidate; and third, an intensive reflexive thematic analysis of a large public data set on fidget objects and their associated meaning for participants.

Following these three theoretical studies, the project was developed into a fidget object prototype and further evaluated. For results of these activities, please see the chapter on “Prototyping and Evaluation.”

3.1. Researcher Self-Study

> *“The parallel role that the researcher takes is an experiencing human being (not necessarily a design professional) who not only directly lives the subjective experience under study, but also documents and analyses it”* – (Xue & Desmet, 2019, p. 45)

The researcher self-study was envisioned as an introspective, autoethnographic Experience Sampling exercise designed to log fidgeting behaviors as they occurred and force reflection on the impetus for that fidgeting. Autoethnography (for our context) can be defined as a ‘qualitative research method that uses a researcher’s autobiographical experiences as primary data to analyze and interpret the sociocultural meanings of such experiences’ (Chang, 2016). Such a focus on autobiographical experiences necessitates an introspective stance and a willingness to position one’s own experiences amongst others and uncover interrelations. Introspection is not universally applicable, however, with early champion Stephen J. Gould, in a rebuttal to a critique of the method, defining two required components: ‘the researcher as instrument-subject must be knowledgeable and motivated with respect to both introspection and the topic of study’, and ‘the topic must be susceptible to introspection’ (Gould, 1995).

Figure 23. Introspection

3.1.1. First Study Attempt – Solo Introspection

Initially, this study was attempted as a singular participant, intensive autoethnography. We later moved to an intersubjective experience sampling of 3 researchers due to the difficulties encountered in progress and a revised understanding of the desired outcomes. In plain terms, the individual self-study did not meet expectations. The greatest barrier was the time-intensiveness and consistent focus necessary to track one’s own complex human behavior throughout the whole day. Further, the research questions were very broad in scope, and answering all at once was too challenging. Partially due to these broad questions and partially the structure of the reporting form, repeat answers were seen after only a few submissions. As such, the data capture method would need to be revised (the original survey is included in Appendix C. Luckily, this study well informed the second iteration through some key changes.

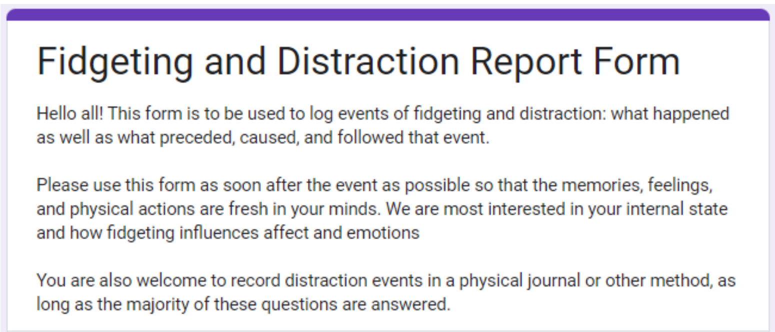
Changes for Second Iteration:

First, we moved away from quantitative, Likert scale responses towards a more qualitative and narrative approach. As the project focuses on such complex and abstract topics as emotion and inner experience, the quantitative methods were not adequate in this moment. We also clarified the definitions of fidgeting and distraction for this research context, aggregated from multiple dictionaries with self-generated adaptations.

> Fidgeting - an interaction secondary to one's focus task. It is often playful, repeated, and exists partially on unconscious level. It consists of continuous, small physical movements that interact with physical objects or one's own body, with no clearly established purpose.

> Distraction - "a diversion of attention; a thing/event that draws someone away from concentrating on something else. Marked by a complete shift of attention from one focus to another that requires conscious recognition of the distracted state to refocus on the task at hand."

By providing a clear boundary for fidgeting and distraction, our study participants were better able to recognize their own behavior and appropriately log via the experience sampling forms. Lastly, we restructured the experience sampling reports to be "event triggered," meaning one was to log a fidgeting experience immediately as it happened instead of at a fixed time. This allowed for better capture of the experiences themselves without being tainted by the passing of time or biased recall and reflection (Csikszentmihalyi & Larson, 2014).



Fidgeting and Distraction Report Form

Hello all! This form is to be used to log events of fidgeting and distraction: what happened as well as what preceded, caused, and followed that event.

Please use this form as soon after the event as possible so that the memories, feelings, and physical actions are fresh in your minds. We are most interested in your internal state and how fidgeting influences affect and emotions

You are also welcome to record distraction events in a physical journal or other method, as long as the majority of these questions are answered.

Figure 24. Landing Page for Fidgeting Report Form Version 2

3.1.2. Second Study Attempt – Intersubjective Study

We chose to utilize three researchers in parallel with the intent of comparing outcomes for all three; while self-observation is a subjective and biased process, if all three researchers recorded similar experiences, intersubjective comparison would suggest that common phenomenon is significant and merits further investigations. Intersubjectivity can be seen simply as "shared understanding" of a concept. Our research questions recentered on focus and distraction, and how fidgeting affected both concepts and their intersection. We sought to answer:

1. What do I interact with when "distracted?"
2. What causes me to lose focus?
3. How do I feel before, during, and after getting distracted?
4. What do you do to end distraction phase (refocus)?
5. Does fidgeting event/distraction prevent one from accomplishing desired task?

The data collection survey was modified to fit these refined research questions as described in the prior section, but had some small additional changes made not directly inspired by the first study. This edition of the survey is available in Appendix D.

Results

Due to temporary leave from university amongst other barriers, participants were not able to utilize the survey and record their experiences at the expected frequency. Still, within a few responses, each participant was recording experiences that functionally duplicated earlier results. Each participant demonstrated internal consistency in the manifestation of their fidgeting experiences, and some common themes emerged between all three. Through a discussion on the reported contents of the study and an analysis of recorded quotations, the following findings were agreed upon:

1) The study had a built-in assumption that a) fidgeting was a behavior explicitly decided upon and b) the aim of this behavior was to regulate stress and anxiety. However, none of the participants could tie explicit emotional aims to their fidgeting. One participant suggested fidgeting was not a distraction, but rather "a natural part of reading" when conducting literature research. As such, the proposed motivation for fidgeting behaviors needs to be reconsidered.
2) Fidgeting was perceived as an automatic and almost unconscious

behavior.

3) The manifestation of fidgeting for any one individual is often the same instance after instance. Users have distinct interpersonal preferences for objects and movements.

4) People are mostly unaware of their fidgeting behavior, at times only becoming “aware of it after the task.”

5) Multiple experience logs considered fidgeting actions to be a component of focus or concentration on a primary task.

6) Many work tasks (e.g., typing) are two-handed and therefore preclude hand-based fidgeting.

7) Fidgeting can manifest through corporeal movements in absence of a handheld object.

Changes to Project Scope and Aims:

Given the results of this explorative, introspective experience sampling study, we modified the scope and aims of the project for more fruitful pursuits. Chief among the changes is a shift to “affect regulation” as the main target in place of “emotion regulation.” Affect is a broader umbrella term for our state of being, which comprises both longer term moods and temporal emotions. Specifically, we look to Xue and Desmet’s Mood Typology (Xue et al., 2020) and target enabling a “productive” mood state through interaction with a fidget object.

We also need further research to understand the exact mechanisms by which people select, use, and benefit from fidget objects. At this moment, most use of fidgeting objects appears to be unconscious or “mindless” in support of some primary work task. Can we further validate this and categorize object use? With these conclusions and learnings, we moved on to the second research activity: an analysis of causes of stress in a student population.

3.2. Stress Causes Survey Data Analysis

The second applied research activity is one of convenience and cross-validation. Through connecting with other master’s students, a dataset was made available from survey results on causes of stress. We chose to analyze the frequency of occurrence of specific causes and coping mechanisms in this survey to apply in this project. This dataset is particularly interesting as it has nothing at all to do with fidgeting, and as such we wished to see if people made explicit reference to fidgeting behaviors when discussing their stressors and coping mechanisms.

The dataset comes from a fellow master’s candidate in the Design for Interaction program, Miriam Ayala, who is conducting a project that involves determining causes of stress in daily life and developing resilience tools in response. In pursuit of this, she sent a four-question survey for data collection to a general convenience sample of approximately 80 responses. The questions are (in order), “What causes you stress?” “How do you manage to get rid (or not) of those things, people, situations etc. that stress you?” “Do you manage your stress alone? Or someone helps you through it?” and “Mention something that makes you feel relaxed. Is it a place, person, thing, context, etc.?” Data cleaning, alongside recording errors and difficulties with translation resulted in 71 usable entries that completed all 4 questions. The data is not shared in whole in this report. Most samples are from college age students in the Netherlands or Mexico and the population is biased more female than male (when gender is perceptible from responses). We do not see these limitations as invalidating, as most all people experience some form of fidgeting. Further, many current university students are experiencing heightened levels of stress and anxiety over previous generations, so the potential impact of an affect-regulating fidget object remains high.

Stress Causes

The focus of this analysis was to record the relative frequency of stress causes and coping mechanisms. To do this from free response submissions, each response was evaluated and coded into one or more themed categories. For causes of stress, we finished with 13 specific stress cause categories, all of which fit under 4 umbrella categories. The specific cause categories are uncertainty, perfectionism, achievement need, lack of control, fear of failure, expectations, finances, deadlines, social relationships, dating, lack of motivation, time pressure, and decision making. These fit under the themes of career, school, global issues, and other. Some categories may also have distinct overlaps, such as decision making and fear of failure or deadlines and time pressure. Even still, best effort was made to be precise in categorization.

Three categories of stressor were clearly more significant than the rest. Time Pressure, or “too much to do,” was included in 32% of the respondents’ stressors. Uncertainty followed at 25% and Deadlines at 24%. Given the similarity between time pressure and deadlines, it is clear this is a very significant stressor. We expect this high emphasis is due to the study sample of primarily university students and the frequency of deadlines in their work relative to a more representative population. Surprisingly, lack of motivation only featured in 3% of responses, and dating in 6%.

Above all, there were zero explicit references to fidgeting or fidget-like coping mechanisms. The survey questions asked for enduring and global stressors that affected people over a significant period, and thus interaction with a fidgeting object did not necessarily fit in the expected responses. Even still, the author was surprised at the lack of fidgeting behaviors. When analyzing coping mechanisms closer, however, there are potential applications of fidgeting to suit existing behavioral responses.

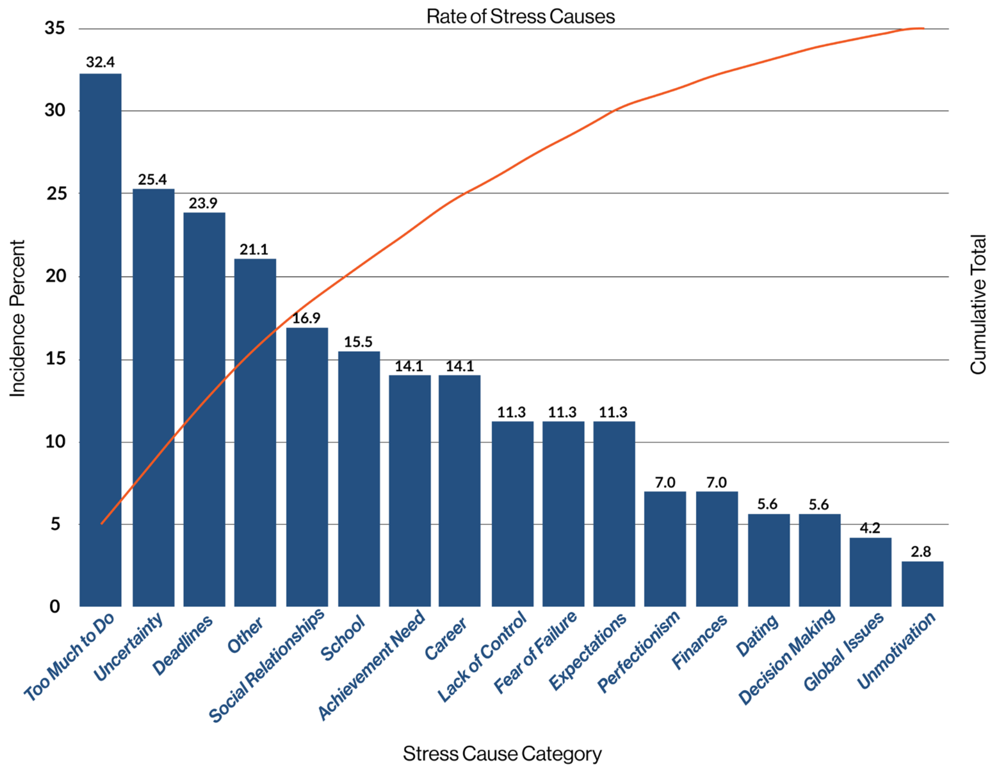


Figure 25. Bar Chart of Stress Causes Ordered by Incidence Percentage

Stress Coping Mechanisms

As with the stress causes, the author coded responses to categorizes responses to stress, which often manifest in the form of "coping mechanisms." This time, however, the categories were determined by preexisting and accepted scientific theory of emotion regulation, more specifically, Gross' "Process Model of Emotion Regulation." As a brief reminder, the following are the five categorical labels

Gross gives to regulation behavior: a) situation selection, b) situation modification, c) attentional deployment, d) cognitive change, and e) response modulation (Gross, 1998). We stick to the basic formulation of the theory in this analysis, partially to reduce complexity and partial because our dataset is simply short, written responses. We do not have the luxury of face-to-face interaction or video recordings that can reveal so much of one's expression of emotion.

Again, the results are quite clear as only one regulation mechanism stood out: **physical activity,** which is part of **response modulation** and exhibited by 34% of respondents. This category contains mostly references to large-format physical activity like running or working out but can also refer to more localized activities like pacing in one's room or walking to the coffee machine in the office. Additionally, we created a category of "**post-stimulus distraction,**" which references coping activities that are executed after dealing with a stressor and was found in 25% of respondents. This was commonly manifest in activities like watching television instead of/after completing a tough homework assignment or shopping for something in place of studying for an exam. Gross specifies distraction as a part of "attentional deployment," which did occur in 10% of respondents, however most respondents continued to focus on their stressor until it was completed or rendered no longer relevant. Then they turned to distraction almost as "aftercare" for the stress experience.

The most common response was also not clearly part of Gross' regulation model as it involved an external party. 36% of respondents cited their need to "talk it out" with other people, sharing in their stressors and successes. The author believes this frequency of response was also biased by the entire third question of the survey which asked people if they managed stress alone or with others while showing a more positive image for 'togetherness." In certain instances, talking about one's stressors and emotions could fit in process model steps, but generally it is not easily categorizable. These results show just how complicated the human stress response is, even when described by an accepted and well-known model. Despite the complexity, we can draw several informative conclusions for this fidget device project.

Conclusions

While no explicit references to fidgeting were uncovered in the data set, we can still apply learnings on common regulation strategies to this project. The need for physical activity in the face of a stressor was hugely influential, and fidgeting is itself a physical activity. We could and should further analyze what aspects of the fidgeting movement can be beneficial in terms of regulating and processing emotion. Most physical activity references in the data set were post-stressor, large in scale, and responsive. What about active or preventative, smaller scale, in-the-moment activity?

The regulation mechanisms proposed by Gross vary in their "intentionality," i.e. some require conscious physical effort (activity) and some mental effort (though suppression). Further, processes like suppression or humor may emerge unconsciously. These differences are indicative of spectrum of regulation mechanisms that are varying parts implicit and explicit. We see fidgeting as a behavior done unconsciously (implicitly), where much of the recorded emotion regulation behaviors have intention and explicit action contained within. Could moving fidgeting towards an explicit interaction give it more emotional regulation power? Is there a way to be situationally implicit and explicit when it best serves emotional regulation goals?

Many respondents (17%) cited meditation and mindfulness exercises as a useful coping mechanism. Where can fidgeting and fidget objects augment these mindful exercises? Is this in conflict with our earlier understanding of fidgeting as a "mindless" interaction? The tensions, between implicit and explicit interaction, mindful- and mindlessness, provide unique design opportunities in creating a complex and rich experience of fidgeting that serves emotion and affect regulation goals in our stressed sample population (and the world at large).

3.3. Fidget Widgets – Reflexive Thematic Analysis

The final (official) applied research activity is the largest and most thorough of the three and concerns a process called Reflexive Thematic Analysis (RTA). The large scope of the data set necessitated a method that could code and synthesize a large quantity of diverse information and derive commonalities and themes from that data. As such, a thematic analysis-type approach was chosen over grounded theory and other qualitative methods, and we specifically utilize reflexive thematic analysis in accordance with the introspective and designer-centric approach for this graduation project. Reflexive Thematic Analysis is supported by a body of research primarily authored by Virginia Braun and Victoria Clarke,

originating from their 2006 paper on "Using thematic analysis in psychology" (Braun & Clarke, 2006). While this specific work does not describe the "reflexive" variant, it outlines the uses of and guidelines for thematic analysis in research, as well as some critical advantages and disadvantages. As Byrne says, "codes (in RTA) are understood to represent the researcher's interpretations of patterns of meaning across the dataset," consciously centering the subjective expertise of the researcher (Byrne, 2021).

The prior two analyses conducted have produced a more nuanced understanding of fidgeting than was initially held, as fidgeting behaviors can now be viewed as subconscious components of affect regulation through physical activity response modulation regulation strategies instead of direct and conscious attempts at emotional self-regulation. Further, fidgeting exists in a liminal space between explicit and implicit interaction, simultaneously purposeful and purposeless. We seek to further clarify perceptions of fidgeting from those who fidget themselves and confirm (or reject) these prior findings through RTA.

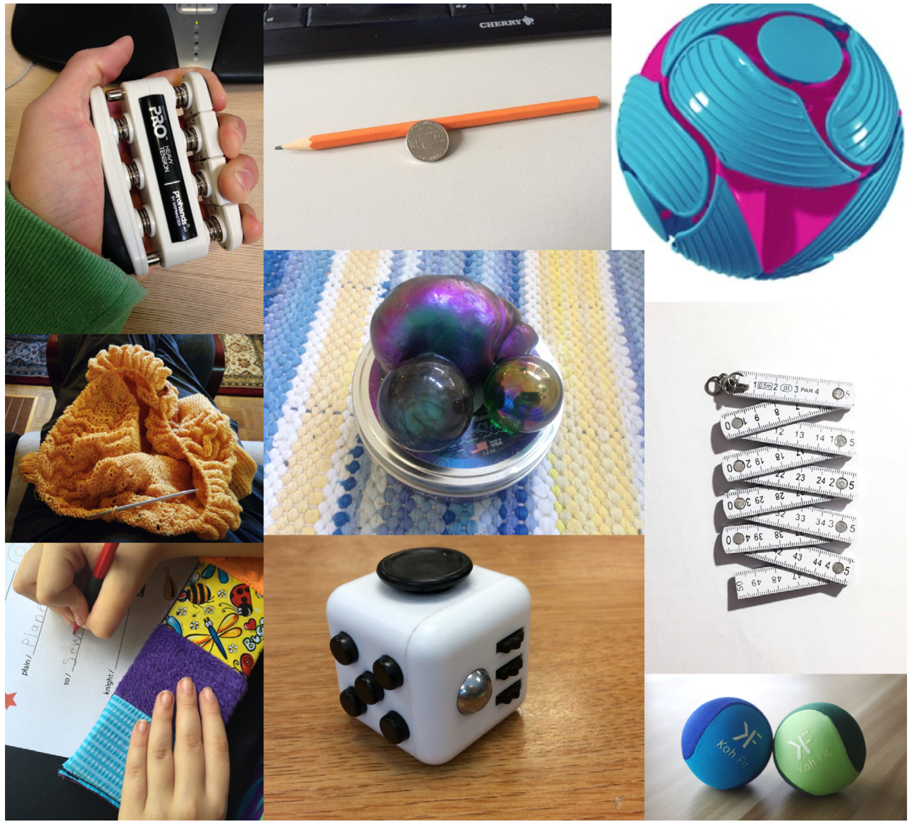


Figure 26. Examples from the Fidget Widget Data Set, own composite

3

The Data Set

The data set used comes from research conducted by Michael Karlesky (in pursuit of his PhD) and supervised by Dr. Katherine Isbister. Their data set features in a 2016 paper they published, naming the objects "Fidget Widgets" and exploring the possibilities for "embodied self-regulation" through these objects (Isbister & Karlesky, Michael, 2016). Immediately, one can see parallels between this topic and my own. Karlesky's work are some of the very few published papers that seeks to understand the power of fidgeting objects to enhance self-regulation, productivity, and creativity (Karlesky & Isbister, 2013). Permission was obtained directly from the authors to download their data set (available at *https://fidgetwidgets.tumblr.com/archive*) and analyze it within my own project, and they wish to clarify that the intent is to allow for public access of their data in any research context.

This data set was collected over multiple years through a Tumblr-based online platform. The project was initially approved by the research ethics committee of New York University and is thus suitable for my own use and future publication, if such a time comes. The data set is comprised of submissions from a representative (global) sample of fidgeters. Each participant submitted a text description of their fidgeting as well as images or video of the "widgets" (Figure 26). The submission portal asked general guiding questions about a participant's submission:

> *"What object(s) do you play with while you work? How do you fiddle with them in your hand? What are they made of? What do you enjoy about them and how they feel? Do they have special meaning to you? When do you play with them?"*

These prompts generated a diverse set of replies, with many participants skipping some questions and choosing to focus on those that resonated with them. We therefore consider the data to be relatively unbiased by the prompts or data collection methodologies (especially as compared to the prior analysis on the stress causes data set).

The submission portal has remained open over the years, and the dataset has grown since Karlesky and Isbister's last publication on this topic six years ago. This provides additional value to this project and its analysis of the data set over

the original grounded theory approach of Karlesky and Isbister, beyond the implementation of RTA as a new method.

3.3.1. Reflexive Thematic Analysis Approach

The Reflexive Thematic Analysis process is not necessarily complex, but each of the six steps do necessitate a lengthy description. In the interest of brevity, we explain only the key points here. TI can highly recommend Braun and Clarke's own website, https://www.thematicanalysis.net/, as a resource for understanding the method. I am greatly indebted to their publications and clear guides and examples of RTA in action. Also frequently consulted is David Byrne's recent publication detailing a "worked example" of reflexive thematic analysis (Byrne, 2021). As the method has been updated over the years and contains some interpretative nuance, a contemporary example was incredibly helpful. Consulting these resources helped me to appropriately follow the six-step recursive process to analysis proposed by Braun and Clarke. These steps are listed by name in Figure 27, and again a detailed description can be found online or in the cited works of this section.

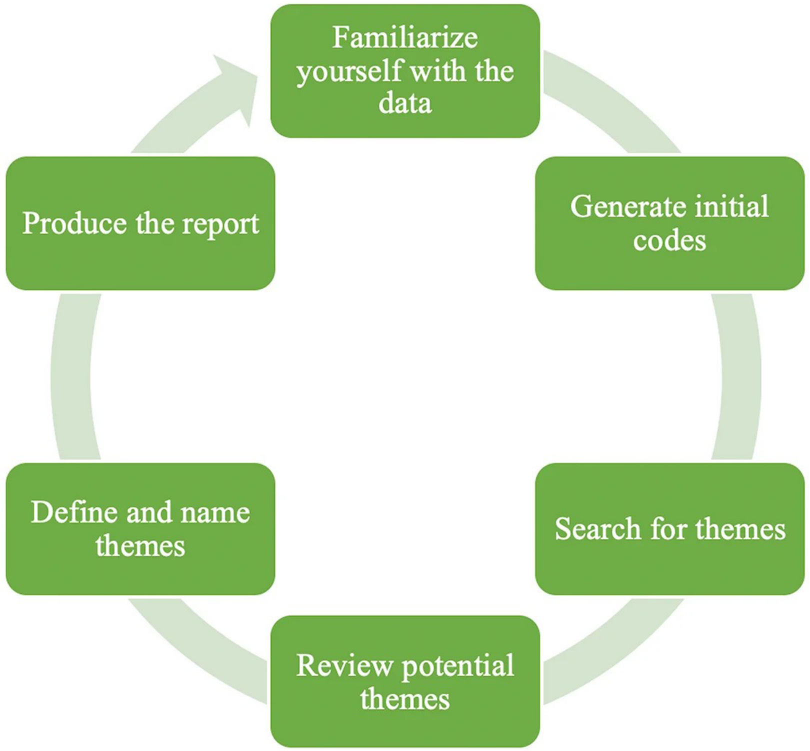


Figure 27. Reflexive Thematic Analysis Process. Ustuk, from Braun and Clarke

RTA also emphasizes that the six-step process is not linear, but rather should be addressed recursively, with movement back and forth between the steps. In this way, codes can be refined to match candidate themes, and clusters of themes are evolved as the shape of a theme itself changes.

Given this fluid and recursive approach, a chronological reporting of the RTA process is both inauthentic and not of much value to this report. While the complete set of codes in included in Appendix E (as are the preliminary themes), the following sections will share the theoretical assumptions taken in structuring the analysis, the guiding research questions, and the outcomes in a discussion style format, alongside a visual thematic map and selected data extracts and analytical narratives.

Guiding Theoretical Assumptions

Braun and Clarke consider four different spectra to exist that determine a researcher's theoretical assumptions when beginning a reflexive thematic analysis. Conscious reflection on (and positioning within) these spectra is required to create appropriate answers to the research questions and understand how to interpret one's findings (Clarke & Braun, 2014). The four spectra are essentialist v. constructionist (epistemology), experiential v. critical (data interpretation), inductive v. deductive (analytical stance), and semantic v. latent (data analysis depth). We utilize an epistemologically flexible approach to RTA, with an insistence on experiential interpretation and bottom-up, inductive worldview creation. We also analyze the data for both semantic and latent meaning. Given this project is entirely centered on one's lived experiences with fidgeting, we use a strictly experiential orientation with a desire to "reflect the experience of a social reality" rather than the "constitution of a social reality (critical orientation)" (Byrne, 2021).

RTA Research Questions

The main project research questions were modified and further specified to best suit the RTA process and contents of the data set. First, we derived six research questions from the originals. Of those six, three were seen as practical and applicable for RTA, and the other three were left to be answered later through more general analysis of the data set (in a manner like the stress causes analysis). The three questions answered in the thematic analysis are all under the general topic "how is fidgeting perceived?":

1. What are individual and group attitudes towards fidgeting?

2. What is the importance and meaning of fidgeting?
3. What is the use of fidgeting?

After many days of research and analysis, the above questions were answered (or at least explicated) through a thematic map and supported by analyzed data extracts. The outcomes of the RTA process are found in the following two sections.

3.3.2. Thematic Map

The two main outcomes of this process are a visual representation of themes and their connection (the thematic map, Figure 28) alongside the narrative extract analysis. The map contains all 6 main themes and 6 subthemes, with "Inherent, Ongoing, and Extensive Fidgeting" as a central origin theme for all others.

While the narrative extracts explain each theme in detail, the map itself should be covered briefly. A thematic map helps visualize "at-a-glance" the interrelations of each theme and how they originate. We consider the central theme to underpin all others, in that the existence of fidgeting as a pervasive and inherent behavior means that it can have such a wide range of impact and influence. On the left side of the map, we see how fidgeting relates to one personally and socially, as fidget objects can become part of one's self-created identity. Additionally, people often develop personal and intimate connections with those objects, which are often never meant to be fidget objects in the first place! Thus, we see how ongoing fidgeting behavior has consequences on personal and social identity.

On the right side of the map, we cover the aims and effects of fidgeting. Users pursue a form of physical mindlessness whereby their hands are occupied in movement without the need for conscious thought processing. This can have multiple goals, primarily as it relates to regulating cognitive function. Fidgeters perceive their actions to help both with attention and with creative problem solving. As mentioned earlier in this report, scientific support for these perceptions is often inconclusive, yet what is important is that a user *believes* in these effects. Users also leverage fidget objects to regulate negatively-valenced affective states, such as stress, distraction, and anxiety.

Hopefully the layout of the thematic map is clear for the reader. Any questions as to how and why a theme was generated will likely be answered in the narrative extract analysis that follows.

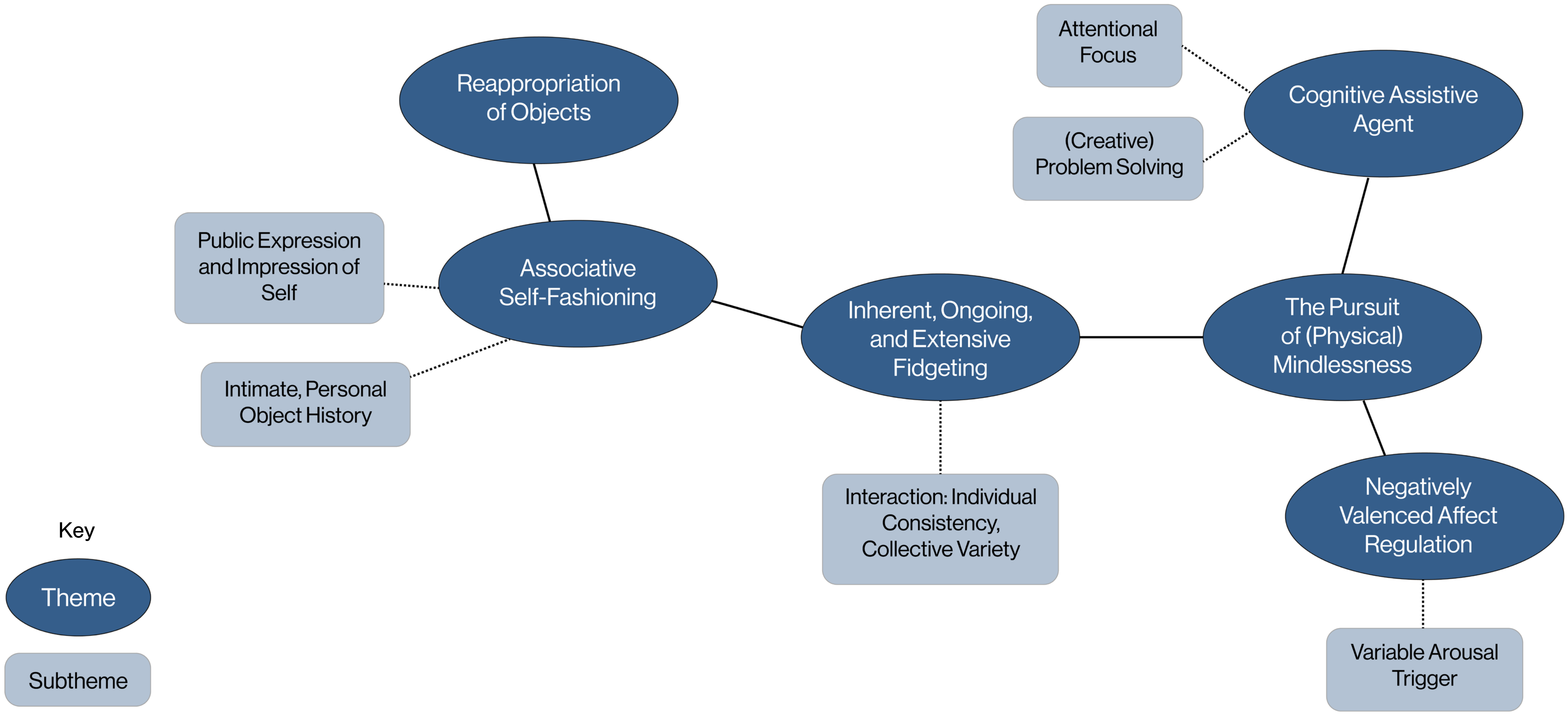


Figure 28. RTA Thematic Map, own image

Narrative Extracts and Analysis

Given the scope of this project, all quotations and extracts come from the comprehensive Fidget Widgets data set which was organized by Karlesky and Isbister (2016). A prototypical RTA process likely uses a dataset with less participants but longer and more informative interview-style data, so while we followed the RTA process methodology, we recognize that our limited depth of data in each submission may limit the narrative and analytical ability of our write up. The main goals of the analysis are defined by Braun and Clarke, saying "Each extract should be interpreted in relation to its constitutive theme, as well as the broader context of the research question(s), creating an analytic narrative that informs the reader what is interesting about this extract and why" (Braun & Clarke, 2012). Accordingly, the nuance and meaning of each main theme in discussed through an analysis of some of the data extracts that informed it, with the aim of fully explaining the range of factors that make up our collective perception of fidgeting.

The author recommends reading this narrative writeup if one has both the time and interest in discovering the underlying motivations for the thematic map. It is rather time-consuming. Otherwise, feel free to skip over the pages with grey backing and continue reading the report afterwards.

3

3.4. Other Results from Dataset

While RTA was a very valuable approach for understanding the broad perceptions of fidgeting and situating our knowledge and exploration in that space, this data set also had much to offer in terms of actionable and specific traits of fidget objects that we can apply in this design project. After the RTA process, we went back and counted the frequency of occurrence of key codes and themes, as well as making some "judgment calls" on what appears to be important. These are some of our main findings from this process that very directly informed the concept development and prototyping stages.

Object Characteristics:

- Most fidget objects are secondary uses of an object (what Norman would call "unintended affordances")
- When users enjoy squeezing interactions and soft materials, they prefer "malleable" but not "squishy" materials.
- Fidgeters often enjoy objects that "fight back" against their movement (force feedback).
- Many people seek "hard" and cold stuff tactile qualities, which often manifests in objects made of metal and wood materials.
- Most commonly, users cite swinging/rotation elements as pleasurable and desired.
- One's choice of fidget object is primarily driven by 1) tactile and 2) auditory feedback. The choice of object is also heavily influenced by social norms in work, school, and office environments.
- Bodily (corporeal) fidgeting has strong learned negative associations and is stigmatized.
- Convenience and availability are critical factors influencing selection of fidget object.

Behavioral Characteristics:

- Generative and creative fidgeting is perceived as higher value than non-instrumental fidgeting.
- Much of fidgeting is done while on the phone or in conversation with others. Other common uses are in situations where purely mental effort is required.
- Most fidgeting takes place in a work environment surrounded by other people.

- Fidgeting behavior is often "mindless" and not recognized by those who exhibit it.
- We postulate that force and frequency of fidgeting movements correlate with the amount of "arousal" in negatively valenced affective states.
- Sensory pleasure is one desired outcome of fidgeting.
- Customization of fidgeting experience can make objects more suitable for a user.

4. RTA Writeup

Theme 1: Inherent, Ongoing, and Extensive Fidgeting
Subtheme 1: Interaction: Individual Consistency, Collective Variety

Perhaps the most widespread conclusion to draw from this thematic analysis is the that the general incidence of fidgeting behaviors is extremely high. It is a pervasive behavior in many environments and contexts but is often not discussed or even noticed. Fidgeting behaviors also contain a lot of variety, some people only use their body where some love spinning pens and others clicking buttons. There is functionally infinite variety in the ways people choose to fidget. Very crucially however, we find that any one individual exhibits a surprising amount of consistency in their choice of fidgeting interactions. More clearly stated, someone who enjoys spinning a ring on their finger is likely to enjoy that one ring-spinning motion more than any other fidgeting actions and continue this one action indefinitely.

> *"I got this ring when I was ten, and I've worn it for eleven years. I can't remember a time where I wasn't absentmindedly fiddling or getting my fingers trapped in it, especially while working at my desk. I pretty much play with it any old time though - watching tv, while arguing, or when anxious. [P015]"*

This extract describes fidgeting behavior that has lasted for more than half of the participants lifetime without modification or significant change. It has become part of their fabric of being (theme 3) and is used mindlessly (theme 4). The fidgeting is not just contained to an office setting, but rather that it occurs throughout the day and in a variety of contexts. Some uses are non-instrumental, i.e., without explicit purpose, but other time the participant is trying to regulate their own anxiety using the fidget object (theme 5). As one can see, this small extract can already share a great deal about the perception and real-life use of fidgeting.

> *"I somehow got into the obessive(sic) habit of pulling out the actual "ink pen" component and chewing on the plastic shell. I hold them in my hand while I'm chewing, mindlessly twirling them around in between chomps. As you can see by the picture, I chew them to literal pieces... When I do travel to one of my company's offices – I still chew them and ensure I grab a handful to put in my laptop bag when I'm packing. I'm a writer and creative-type, so I find the mindless chewing a must while I'm working or doing just about anything on the computer... I even have a specific type of pen that I prefer – and buy them in bulk at BJ's or on Amazon. [P079]"*

> *"Knitting is the perfect fidgeting for me, because not only my fingers do the same action for about 90,000 times, while I can turn my focus inwardly and ponder for hours on end, but also it produces something tangible that I can use. [P122]"*

The data reviewed demonstrates three distinct groupings of people who fidget: goal-negative, destructive, and constructive. Goal-negative fidgeters have no specific desired outcome or byproduct from their fidgeting, like participant 15 (alongside many others). Destructive fidgeters are (logically) destroying the object they fidget with as a component of the fidgeting process, like participant 79 with their pen ink cartridges. Constructive fidgeters are generating some artifact through their fidgeting behavior, and preferably one they see as valuable, like participant 122. Each class of fidgeting brings expectations of the fidgeting object along with it; for example, a destructive fidgeter will likely only use a readily available and low-cost item as it must be frequently replaced. Some, like our example, even bring their fidget objects with them when travelling for work as they feel the object is "a must" for productive work. Productive fidgeters will often utilize equipment alongside a consumable (e.g., yarn or origami paper) and have a more structured approach with a planned and desired outcome. Goal-negative fidgeters cover the range in between, with a variety of objects and desired interactions.

Within these groups, there is still often overlap in the interactions sought and therefore we can uncover some common behaviors and fidgeting actions. These are discussed in relation to prototype development outside this of this section of report. Also key is the lack of purposeful action or desired outcome from fidgeting. While many people have come to recognize benefits for themselves in terms of focus, cognitive performance (theme 6) or affect regulation, most fidget in a "mindless" way, unaware of the moment-to-moment effects of their actions.

Overall, these examples and many others demonstrate the absolute breadth of fidgeting behaviors and their motivations and manifestations. We do not feel the need to classify or somehow evaluate every single one, and simultaneously recognize that no singular product will be the "right" fidgeting object for all people. Accepting that truth, the three proposed categories and deepened understanding of the pervasive and somewhat unintentional nature of fidgeting will serve us well in designing ideal interactions for the largest group of users.

Theme 2: Reappropriation of Objects

This finding is likely unsurprising to those who fidget, but the reality is that most fidget objects are ones of convenience. Given much fidgeting occurs in educational and office work contexts, pens and pencils, paperclips and binder clips, paper itself, and other similar supplies are very often integral in the fidgeting process. "Convenience" can even be something you already had on hand, even if the object itself is an uncommon item.

> *"I stole this wooden chew toy from my 10-month-old baby to play with at work. I gave it to him in a pricey baby boutique to settle him down so I could finish my shopping but all the time thinking, 'This is really for me. This thing is so pretty and feels so nice.' He kept it for almost a week and then today I thought, 'Maybe I'll just try it out one day'.... [P011]"*

Participant 11 (somewhat) shamelessly took a chew toy for her young child for her own fidgeting use in the office. This toy was explicitly for use in a "play" context, so it is not super far removed from the act of fidgeting itself, but still we see a "reappropriation" of a device meant for another use context. The participant feels some form of shame over their actions, partially due to taking something from a baby, but also due to the stigma of using a tool not explicitly

for use by someone of their age. This sort of use case is not unique, as other participants list toys and objects designed for younger children as some of their most dependable fidget objects. Returning to the theme of "everyday objects," we can also see firsthand how that works in a fidgeting context.

> *Ever since I was a child, I would play with rubber-bands as a sort of safety blanket ; I roll them around in my hands and use them as a stress-reliever . All through my growing up, my parents would know exactly who to go to if they needed a rubber-band ... Now, as an adult, I still have at least one rubber-band on me at any time.... I can also tell if I lose one of the rubber-bands I had been rolling in my hands because of the way it feels. I can tell the difference between four rubber-bands in my hand rather than the five I started out with. [P037]"*

This participant's fidget object of choice is a simple rubber band, a mainstay of any office setting. But here we can clearly see they are taking it far beyond the bounds of its original intended use: as a rolled up, handheld stress reliever. Perhaps more interesting is the emotional attachment to rubber bands, both in the past and present. The participant associates their collection of rubber bands with emotional safety and stress relief, two very abstract concepts.

One could argue that the meaning and importance of these rubber bands is not a latent property of the object itself, but rather that the meaning is created through interaction with the object. This is close to the fundamental tenet of a pragmatist sociological theory called "Symbolic Interactionism," which suggests that humans create meaning through sharing symbolic interpretations with one another to construct shared meaning (Hall, 2007). Somaesthetic philosophy also believes that most meaning is created through personal experience of a phenomena and later sharing of that experience. The point of connecting these theories is to connect our research findings from literature to this data set analysis, and to highlight just how important an "everyday" object can become when utilized as a fidget object with deep affective and personal attachment. As the next theme explains, people are even utilizing fidget objects (intentionally or not) as an element of public expression and definition of self.

Theme 3: Associative Self-Fashioning
Subtheme 1: Public Expression and Impression of Self

Perhaps most unexpected was the extent to which fidgeters became attached to their fidget objects and considered them as a component of their own identity. While it is no secret that many consumer purchases are at least partially driven by public perception (designer goods, luxury cars, etc.), we were surprised to find this correlation within such an unassuming category as fidget objects.

> *"I have a lifelong history of fidgeting that's connected to ridiculous adult nail biting. Super embarrassing. If I'm fidgeting, I'm not biting my nails, but if I lack for a fidget thing I'll bite my nails like a mofo. Quitting smoking didn't help. I brought a koboloi back home from Greece this time, a traditional fidget of worry. The downside is that I look like a Greek uncle who's been sitting at the same cafe for the last 5 years spouting non sensical political/football theories in between backgammon sessions. Don't get me wrong, I'll get there eventually [P006]".*

The participant relies on a fidgeting object that they purchased back in their home country (Greece) and has constructed a self-critical perception due to their choice of this object. They see the object as representative of a specific archetypal person in their culture, one who is aged, mildly senile and most definitely not the vision of a young, productive, and successful person. The participant feels a shame or stigma for having chosen to rely on this object. However, an outsider to Greek culture may only recognize the object as a Greek artifact and not understand the underlying stereotypical associated identity. Or perhaps they do not even recognize the koboloi beads as Greek and have no preconceived notions of the object or object owner at all! Thus, the use of this fidget object creates identity on multiple levels of specificity and cultural connection. No matter on what level it is interpreted, the fidget object still acts as a component of one's public identity, at least in the context of use.

This identity is not only self-created and self-observed, but also given through

interactions with others in one's social context. Fidgeting behaviors (like any other outwardly visible behavior) will influence this public identity. Fidgeters, however, are often concerned about stigmatization of negative appearance. Unfortunately, fidget objects and behaviors can become a social divider depending on the use context and scenario. This is a logical conclusion to anyone who has ever worked in an office with a pervasive pen-clicker or foot-tapper and dealt with the feeling of annoyance and discomfort within. However, there is more nuance than just this universal hatred of fidgeting. Our analysis found that both fidgeters and the objects themselves can develop a split perception: some objects are seen as desirable and as fascinating, where others develop a stigmatized reputation. The same is true for users of the fidget objects.

> *"The creation aspect of making pieces, fitting the pieces together, and yielding a compact little ball was very satisfying. The process is repetitive enough to make it mindless and not distracting to note taking. I have had several teachers and managers give me the stink eye for it and an equal number of people who are utterly fascinated to watch me make something in under 60 minutes [P069]".*

This participant clearly references the split perception of their fidgeting behavior (and thereby of the person themselves). Interestingly, most negative feedback seems to come from superiors, while fascinating is from generic "people." Perhaps people in management associate fidgeting with a lack of attention or focus? In this instance, the fidgeting behavior is a generative skill (origami) which we also see to influence perception by the fidgeter. The more a fidgeting behavior generates a useful or artistic product, like knitting or origami, the more likely they are to see it as valuable.

> *"Reading through some of the submissions on your page, I am now wondering if all these years, I was just looking for something healthy to fidget with (and that I don't have an addiction or mental problem for wanting to use my hands when I'm anxious, bored, or deep in thought [P166]".*

People who fidget have often been conditioned to see their fidgeting behaviors as abnormal or unhealthy. In this case, the participant's mother shut down their fidgeting behaviors while young which contributed to unhealthy skin picking habits. Even the simple existence of the online Tumblr data set is enough to show this person that fidgeting behaviors are normal and should be acceptable. They had considered fidgeting as a portion of their identity that painted them in a negative light (lack of self-control, etc.). It is clear just how powerful social context and acceptance are in our own identity creation.

Subtheme 2: Intimate, Personal Object History

We also observe the long-term possession of fidget objects. In these instances, the fidget objects are acting as keepsakes or as talismans of the past, and people are developing an ongoing personal history with the object.

4

> *"This is a piece of painted concrete, I found it outside my workplace (in Sydney, Australia) on the Street and decided it was likely to be flicked up by passing vehicles potentially injuring someone. It has been with me on my desk and fiddled with through 8 years and three jobs. It's now with me in Seattle, USA and I fiddle with it all the time [P098]".*

We can all agree that, while some chunks of concrete may be of cultural or historical importance (e.g., the Berlin Wall), this specific piece of concrete has no inherent meaning or significance. Or at least, it had none until it was collected and used as a fidget object by the participant. Logically, there is no reason to move a piece of concrete across the world and through a multitude of jobs, yet this participant has done just that. Why? The object develops an intimate and personal history with its use over time, becoming much more than a simple object and instead a physical manifestation of experiences and interactions over time. The participant might even begin to associate that object with a specific affective state or experience, as another participant did.

> *This is my stress ball, which is shaped like a brain. I got it forever ago in eighth grade and have used it so much it's unrecognizable now. It was given to me by someone who knows how passionate I am about neuroscience, and it has been my best friend ever since. I find that squeezing it with the bottom flat on my palm and the rounder top under my fingers feels best, but simply having it around me on the desk or in my pocket is comforting. I have a lot of anxiety that would be unmanageable without this little guy. I never go anywhere without it. [P154]"*

Participant 154's experience is significant in more than one way. First, it too was a gift from a close friend, and as such already had some embodied value. Another participant kept something even longer, sharing *"this is a toy my grandfather gave to me 20 years ago. [P054]"*. There is an immense power in personal attachment to these fidget objects, especially when given or created by an important external party. Next, participant 154 clearly articulates the value of this fidget object in their life: it has become an anxiety management tool. Whether this is for the physical squeezing interaction itself or the years of embodied memories, struggles, triumphs, and emotions is unclear. Most likely, the participant perceives some combination of both of those uses in episodes of anxiety. The participant has developed a learned behavior of squeezing this object in moments of anxiety and perceives relief for it.

Even more participants tell of their ongoing attachment to fidget objects:

> *"In my backpack, I keep a labadorite stone sphere I've had since 1999 and some Crazy Aaron's thinking putty. In my shoulder bag, I keep a glass marble I picked up in Stockholm a few years back [P062]"*

The analysis thus far is clear and adding more extracts does not necessarily strengthen the point being made, and so we will stop with these three for the moment.

Ultimately, this is a critical insight for our aims in affect regulation through fidgeting. Whether or not a fidget object has scientifically verifiable health benefits and aids in affect regulation or not, use over time and absorption into personal identity can render a fidget object both useful and significant to its owner. If we can develop an object that encourages this adoption as a significant artifact, that object stands a better chance of utilization over time. It seems that people may even latently understand the importance of the choice of fidget object; more than one reference the ongoing pursuit of an ideal fidget object, and as one said, *"I am currently on a journey to find something to fidget with [156]".*

Theme 4: The Pursuit of (Physical) Mindlessness

Another trend found in the data was reports of fidgeting as an escape behavior, but not escape in a literal sense. More precisely, participants leveraged fidgeting as a cognitive break of sorts, allowing their hands to move with very little concentrated effort, helping release their mind and thoughts from a felt need for movement. Frequently the words "unconscious," "subconscious," and "mindless" were used to describe participants' own behavior. In this construction, participants keep their hands and body "occupied," constraining it in a small range so that their need for physical movement cannot interfere with a cognitive focus task. These findings closely align with the proposed Reflexive Focus Bounding theory. Themes 5 and 6 are two branches of this theme that point to specific uses of this physical mindlessness, but the phenomenon is worth addressing in and of itself.

> *"I just need something to keep my hand occupied with as I process my thoughts. There is always a part of me physically tapping rubbing or scratching. [P082]"*

> *"I always touch my lip with my left index finger while I work. When I get really deep into something, I stroke it back and forth like a tiny violin. I never noticed I do it until someone pointed it out to me. [P010]"*

> *"My favourite thing at the moment is that I twirl rulers around pens. I also swing my necklace round and make patterns amongst my fingers when it lands, sometimes it flicks off and gets lost, and sometimes the ruler flies off an other(sic) people. I sometimes put my calculator on its corner and make it spin too. I do it all without thinking. [P059]"*

This theme is not as deeply analytical as some of the others thus far, but the point made remains important and significant. Many fidgeters have no conscious conception of how, when, and why they fidget. Some are adept at retrospectively understanding the "what" component (as our extracts here demonstrate) but few seem to understand the core "why." Further, some people, like participant 10, are not aware of their fidgeting behavior at all until alerted to It by an external party. It is hard to imagine that this behavior is causing any sort of effect in the person if they don't know they are behaving in this way. Classical theorists have suggested a link between occupied hands and a sharp mind, but contemporary science has not yet proven such a theory. The point of this analysis is not to add fuel to that fire, but rather to simply confirm that the popular perception of fidgeting (by those who engage in it) is that the behavior is largely mindless, unintentional, and often unrecognized.

This graduation project is founded on the hypothesis that these mindless, unintentional, and often unrecognized fidgeting interactions can be leveraged as an affect regulation tool, which (luckily for this author) is a perceived effect of fidgeting interactions and can be seen in our fifth theme, below.

Theme 5: Negatively-Valenced Affect Regulation
Subtheme 1: Variable Arousal Trigger

A critical outcome of fidgeting is regulation of negative affective states, specifically stress and anxiety that are predominantly work task-related. The entire foundation of this graduation project is the assumption that fidgeting can be used as an affect regulation tool, so to see it represented well in the thematic analysis in encouraging. We see that participants utilize their fidget objects for regular intervention of these states, for example:

> *"I fidget with a bracelet that I keep on my wrist at all times. I sometimes find myself fiddling with the bracelet mindlessly. I personally find fidgeting useful at times when I am anxious or on edge about something. It keeps me distracted from being bored however it helps me have a better focus at the task I am trying to accomplish. [P171]"*

Participant 171 hits all of our key words in one entry, with mindless interaction and feelings of anxiety, boredom, and focus! Significantly, regulation of anxiety was the first effect listed. This participant can also elaborate (albeit briefly) on the sensation of anxiety, calling it "on edge." A surprising find is that most submissions mention boredom and anxiety in the same sentence, or at least without providing much of a distinction between the two. For example:

> *"I use these things when I am in a class that isn't conducive to note taking, when I'm having a conversation that I am worried about, or when I am bored. Hope this helps! [P145]"*

> *"I like to squeeze my Pokeball stress ball and play with my plastic Slinky. The Slinky looks really cool and gets me to stop staring at my screen for a second. The Pokeball is fun to squeeze and is easy to throw to my coworkers who want a chance to squeeze it themselves. I play with them when I feel bored or anxious. [P077]"*

Participant 145 has "worried" followed quickly by bored, and participant 77 mentions "bored and anxious" back-to-back. While there is nothing wrong with these self-reports (as there is no right or wrong in personal, subjective matters), boredom and anxiety are normally seen as very different, if not opposite emotions. Considering the vector-based models of emotion, anxiety is a high arousal state, where boredom has very low activation or arousal, though both are negatively valenced. It would be a safe assumption that fidgeting behaviors differ in response to these two emotions, yet the participants do not mention how or if that is the case. This could suggest that participants struggle to differentiate their fidgeting behaviors based on affective state. Such difficulty would render a fidget object with affective sensing quite powerful and a large step forward in affective self-regulation. It does seem some have 'cracked the code," however:

> *"People call it 'pen-spinning'. I do this when I'm stressed, bored, or thinking. The speed of the spin is directly proportional to how stressed I am: increased stress = increased speed. And vice versa. [P144]"*

One participant has insightfully linked their physical fidgeting interaction to their internal affective state. A higher speed of pen spinning represents more stress. This link is both critcal and impressively self-aware: If fidgeters at large

exhibit this same behavior, we can design a fidget object to leverage this as a source of data and respond appropriately to encourage self-regulation.

Ultimately, we see fidgeting behaviors and being triggered at various levels of arousal, from the low activation of "boredom" to the high activation of "anxiety" and "stress." The majority of fidgeters can identify these emotions (affective states) but did not distinguish between different fidgeting behaviors that may occur for different affective states. We expect and observe that such a variance in behavior does exist, so there exists a unique opportunity in sensing, identifying, and operationalizing these behavioral differences to aid in affective self-regulation.

Theme 6: Cognitive Assistive Agent

When there is a recognized or perceived benefit to fidgeting, most participants consider it be one of two things: increasing creativity or helping guide attention and focus on a primary task. Both fall under our category of "cognitive assistive agent," as each outcome boosts the productivity of the user.

Subtheme 1: (Creative) Problem Solving

> *"I always find myself fiddling with an old coat toggle. It fits so easily in the hand and all my fingers can play with it in many different positions . The spring always feels so satisfying to squash and release when stuck finding that creative breakthrough , and it always helps, even if just for a moment of procrastination! [P016]"*

> *"I am a software developer, and often need to sit back and come up with creative solutions. Absentmindedly playing with this toy seems to jump-start the creative process. I usually play with it until my fingers need to jump to the keyboard. [P031]"*

While these extracts do not offer much more than surface level interpretation, it is clear to see that both perceive a link between creative manipulation of fidget objects and creative breakthroughs. Most interesting is how both participants do not reference use extensively during the creative process, but rather as a springboard off which they can jump into a creative process with momentum and overcome roadblocks or starting inertia. Other extracts mirror this sentiment, suggesting that the creative process is intensive and requires full focus once engaged, but the process of engaging and making "progress" is a hurdle.

Both extracts refer to rather static and one-dimensional fidget objects with a limited range of manipulations and sensations. This is in line with most descriptions of fidgeting from the data. However, we have a contrasting description of fidgeting in a creative context where the act of fidgeting itself is a creative enterprise.

> *"...the connectors are also just a cool thing to look at themselves and are a great small fidget item. The reason that I really like this toy is that it is open-ended, and I get to actually create new things. It is a bigger creativity escape that a polished rock for example, but not as long as a walk outside. The things I build are also new each time and the builds are adjustable so I can make something and then fidget with the design a bit. I even invented a stand for phone. I do a lot of multidimensional work (IT, programming, modeling) and the use of 3D building is great for a creative escape–on topic but not on task. [P043]"*

4

The participant's choice of words, "on topic but not on task," provides an interesting conceptual framework for their fidgeting behavior. If a generative and creative fidgeting interaction is closely related to a primary task (enough so that it can be "on topic"), will that fidgeting interaction aid creativity throughout the length of the process? The other examples of more static objects seem to provide momentary assistance or intervention, where a dynamic object has more potential over time.

We can classify future designs by their specific goal within providing cognitive assistance to a user. A fidget object that aids in creativity over an extended time should be dynamic, open ended, flexible, and "on topic" even if not on task.

Subtheme 2: Attentional Focus

The second (and more prevalent) use of fidget objects is to guide attention and focus to a primary task, often work or school related. As mentioned in theme 4, many theorists and researchers have tried to definitively link physical movement with cognitive performance, with varying conclusions and quality of results. This thematic analysis does not contribute to that domain and scholarly debate, but rather reveals the felt and perceived effects of fidgeting for real-life users.

The extracts show that participants associate fidgeting behavior with deep thought and focus. There are without a doubt many more extracts that directly mention "focus" than any other theme or topic. The words "focus" or "attention" were not mentioned in the information or response prompt for the data set, so this is not simply an experimental bias either. Below are some of the more concise descriptions of focus effects.

> *"I think it mainly keeps my hands occupied, which focuses my mind on the thing I should be working on and prevents me from becoming distracted with something else. [P060]"*

> *"Working in a corporate environment I have to fidget discreetly and so i find myself reaching for the post it pad and bending it back and forth non stop all day... I just need something to keep my hand occupied with as I process my thoughts. There is always a part of me physically tapping rubbing or scratching. [P082]"*

> *"The blue "fish" sculpture is magnetic, the pieces are metal. I find that visitors to my office, who have come seeking research help, like to play with this sculpture. It helps them focus on their question. As they sort the pieces they seem to be sorting the parts of their problem, then they reassemble the sculpture as they organize their thoughts about their problem and its answers. [P042]"*

Some participants even explicitly mention the situational application of their fidgeting behaviors; sometimes it is for focus, sometimes for anxiety regulation, and sometimes for play. The open-ended use and freedom of interpretation are the most powerful attributes of fidgeting interactions, and we need to keep this ingrained in new designs.

> *"This necklace is my new fidgeting addiction. it has a magnet inside, which makes it extremely satisfying to play with. I noticed I use it in a variety of moods: sometimes it helps me focus, I do it subconsciously, other times its a conscious action that reduces my social anxiety. [P085]"*

The extracts in this section have fed into a theory of Reflexive Focus Bounding that we developed after analyzing this data set and research. Again, it proposes that fidget objects can be used as extended cognitive objects that place limits on what we can think about and on distraction. Fidgeting that would otherwise contribute to mind-wandering is captured and redirected via the fidget object. It is important to note that this is just a theory. At first investigation, there are no immediate objections to this proposal in scientific literature around cognition and fidgeting, but there is also no proof at this moment either (other than this analysis and our body of work). It may just be a theory, but we suspect it would resonate well with many of the fidgeting participants. These extracts provide two examples:

> *"I fiddle with this foam cube thing... I think it mainly keeps my hands occupied, which focuses my mind on the thing I should be working on and prevents me from becoming distracted with something else. I tend to reach for it any time I get writer's block or need a second to sit back and think. [P060]"*

> *"I find myself playing with Airpod cases when my hands are busy... Recently I lost my AirPods and I found myself fidgeting with much more distracting things. I found myself messing with my candle and or resorting to looking at my phone when distracted. Both of these things were much more distracting and made me lose focus. [P168]"*

Participant 60 explicitly references using a fidget object to occupy their hands to prevent further mind-wandering distraction. Participant 169 also reveals that certain objects and devices were significantly more distracting than their preferred fidget object. The complexity of the device itself (especially the smartphone) may have a significant influence on the distraction caused during the fidgeting interaction. While just two quick examples, they are clearly in line with the Reflexive Focus Bounding proposal. And whether this specific theory is later validated, overwhelming evidence points to the conclusion that fidgeters utilize their behavior to aid in focus and attention on a primary task. Whether this is verifiable through research studies or not, these participants truly believe in the effect of fidgeting, and that is functionally enough to motivate further development of design solutions in this space.

Conclusion

This thematic analysis is an exhaustive and exhausting component of the graduation project. In other fields, students will conduct a singular reflexive thematic analysis as the full content of their master thesis, and, due to this, we recognize that this specific RTA might not match their standards in depth of analysis or length of report and cross-theme connections. That said, we feel strongly that this analysis represents valuable insights that would not have been made apparent without this process. This reflexive analysis can be seen embodied in our prototypes and final concept vision.

We now understand better how pervasive fidgeting behaviors are in daily life. People choose to engage with a variety of objects, open reappropriated from their original intended use. Within the chosen object, many people remain consistent and faithful to a specific motion or mode of interaction over long periods of time. These fidget objects can become ingrained in one's identity, either through interpretation by others in one's environment or through a built personal connection and history with an object. This self-fashioning is just one example of how we utilize objects and possessions to structure a personal identity.

Often fidgeting is done mindlessly, but even still, it can serve an effect for the user. Many participants feel that fidgeting is calming or anxiety reducing, regulating negatively valanced affective states towards more positive ones. Outside of the emotional context, users find fidgeting to assist them in cognitive functioning, specifically in the domains of creative problem solving and task focus and attention. All three of these effects contribute to movement towards a “productive” affective state, which is our target for this project. Further, participants can experience a multitude of different effects from their fidgeting behavior, as context influences outcomes. As such, we should design for fidgeting interactions that do not limit the interpretability of the experience.

5. Concepting, Prototyping, and Evaluation

Introduction

After the intensive research phase, we addressed the challenge of translating all the insights gained into a design concept that could be prototyped to embody theory in practice be evaluated (to some extent). This “prototyping” phase opened with a brief review of other products on the market or produced as research artifacts, which allowed us to understand the general landscape and what is possible in this domain. We were inspired greatly by viewing existing products and borrowed many small attributes of a diverse selection in our own prototype and later concept future vision.

Armed with theoretical knowledge and an understanding of contemporary design artifacts, we then laid out goals and aims for our own prototype across the domains of form, material, interaction, and technology. The specific choices we made in each domain are all motivated in the corresponding sections of this chapter. We then detail the time-consuming process of prototype creation and share the results of our workshop evaluation session. All of these steps are an integral part of the design and Research through Design processes, and ultimately feed into our envisioned final concept.

5.1. Use Scenario

To effectively guide the concepting and prototype development phases of the project, a clear and restricted use scenario was developed. We chose to design to a specific use case that is more “restrictive” than most use cases. Through this, we develop a product that can also be readily used in less constrained scenarios. The following is a “written scenario” of a potential user, their needs, and how they interact with a fidget object.

1. Background
   Jim (29, M) is a recent addition to the corporate world. Having graduated with his masters 4 years ago, he works as an analyst in an international

financial office in Amsterdam, evaluating trade risk. His work is mostly digital, reading documents and running calculations. However, Jim's days are frequently full of meetings. His large company has many clients that expect regular updates, so Jim is often a participant in meetings with the internal team and with external parties. He is smart and capable but struggles to remain on task throughout the day, especially in consecutive meetings or those held online. He finds himself full of nervous energy and frequently fidgets with pens on his desk or bounces his leg up and down. Jim feels easily distractable and absent-minded. In a city as big as Amsterdam, there is always something going on outside the windows that is more engaging to draw him away!

Figure 29. Example Use Context (Open Office). From StudioLab

2. Motivations

Like many in the financial sector, Jim wants success. Making smart trades and earning the company big profits is the way to a top position down the line. He recognizes this sort of success requires deep commitment and sometimes long hours. Jim wishes not to stay at the office after hours but needs to finish all his assigned tasks daily. Thus, he really needs to be more

productive with the time he is in the office. Distraction, mind wandering, and lack of focus are in direct opposition to his daily work and long-term career goals. He also recognizes that anxiety over the work to be done is not a useful behavior either!

3. Tasks

The core problem for Jim is that he is not sure what to do to help himself. The office environment is not conducive to exercise routines or running (which he often does when feeling stressed at home). He must not sacrifice too much time on activities to calm anxiety and drive focus, as that would give him less time to complete his work and drive further stress. He needs help in recognizing when his anxiety is impacting focus, or when he begins mind-wandering spontaneously. Upon that recognition, Jim has the knowledge and willpower to pull himself back to the task at hand. Ideally, Jim can leverage his "nervous habits" and fidgeting behaviors to help himself in regulating focus and countering anxiety, all while minimally distracting from his important work tasks. The less amount of effort this take Jim, the more satisfied he is. An affect regulation fidget object is therefore an ideal solution for Jim, and he can engage with it on a regular basis to meet his goals. However, the device itself must fit well into a very specific environment with constraints and rules.

4. Context of use

Understandably, the environment around Jim is very important to how he acts. He works at an open-plan office with tens of other employees scattered about, and meetings take place either in a designated conference room or online. His distractibility is often a function of how busy the office is, yet most people remain quiet in going about their daily work. The open-plan office allows sound to travel far, and any stapler action from the copy room is audible at his desk. His field expects a certain professionalism in meetings that is stricter than most, with nice dress and a demeanor of intensity and focus. Jim wants to use his new fidget object in all moments of his working day, so it needs to be carefully designed not to violate social norms. Important meetings must remain quiet (as does the general office space), and Jim should always maintain an appearance of attention to meeting speakers. Drawing attention to oneself is highly unwelcome in his workspace. The fidget object must be discreet and personal and exist as a valued object with an aesthetic appearance that merits a permanent place on the desk of the user. Perhaps most importantly, Jim must understand the fidget object, and vice versa. It must detect his motor expressions of negative affect and lack of focus and aid him in recentering on his work. If the device can fit into this restrictive scenario, it stands a chance of creating impactful change and helping Jim to achieve his day-to-day and overall career objectives.

5.2. Existing Products

Depending on how we cast our net, the ocean of existing products is both wide and deep. Many new technologies are being introduced in the market that purport to help with affect regulation: The Apollo Neuro wristband uses two frequency vibrations of a specific band claimed to cause affect regulation effects. It also employs a customized and patented equation for determining the “state of the user” and what the vibration response should be (Siegle & Rabin, 2019). On the other hand, we have products like the Grasp stone, which serves simply as a monitor of physical expressions of one’s affective state and logs force-based hand squeeze measurement over the course of a day (Krøger et al., 2015). To make sense of this diversity of products, a selection was evaluated for their features and performance before we cherry-picked the best elements of each to apply to our own fidget object for affect regulation.

Categorization

Existing products can fall into two main categories of fidelity: market-ready consumer goods and academic research artifacts. While sometimes research yields a consumer good, it is most likely that a product is not both at the same time as often research artifacts are less polished and precise. Further, the products themselves exhibit two main interaction modes: wrist-mounted or handheld and manipulable. As many products employ biosensing, the wrist-mounted orientation is useful for measurement stability (discussed earlier) but limited the freedom of interaction.

We also visually arranged and categorized products to find existing gaps in the marketplace that we could target with our design. The categories followed spectra and “tensions” from research, such as level of interactivity and use of biosensing.

Feedback Types

Most existing products exhibited a single feedback type, with many utilizing vi-

bration feedback. This is no surprise as vibration motors and technology have evolved rapidly since the advent of smartphones and can produce a vast array of specific haptic sensations. We see an opportunity to either a) create a market ready product utilizing heat (temperature change) as a feedback mechanism or combine more than one feedback type in a singular product. Figure 30 below, shows just how monomodal each product is.

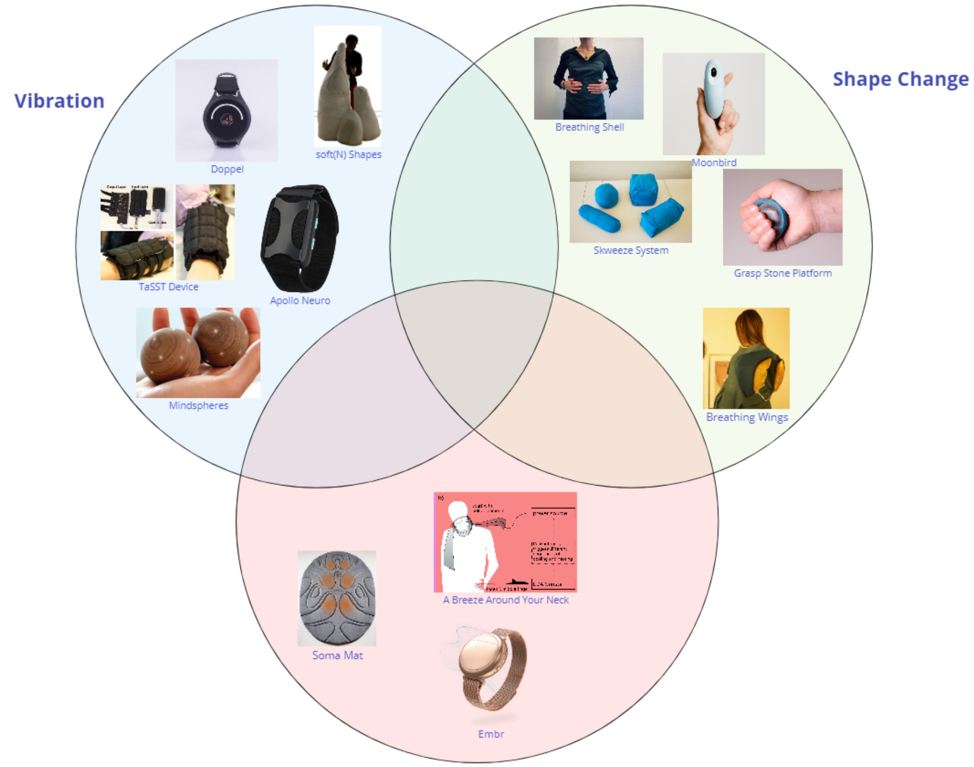


Figure 30. Products Exhibiting Monomodal Feedback, own image

Interactivity

To understand the connection between the “responsivity” of a device and its use of biosensing, we plotted each product on a two-dimensional cartesian plane (Figure 31). This revealed not only a “blank space” opportunity area to create a highly responsive product with minimal biosensing, but also that most highly dynamic and highly bio-enabled products are research artifacts and only one is available for purchase. This makes sense, as the technology and difficult of use increases with this combination, as would the cost of production and support. Regardless, we can use these two potential opportunity spaces to later help direct prototyping efforts.

We also return to the distinction of implicit vs. explicit interaction when evaluating existing products. As our research shows, fidgeting interactions are largely implicit and "mindless," where the user is mostly unaware of their own behavior and object manipulation. To fit this use context (and our aims around achieving a productive mood state), we want to generate implicit interactions with our product. A challenge is to design an object that supports frequent manipulation and contact while still occupying a "mindless" space.

Figure 31. Opportunity Spaces Within Existing products, own image

Existing Products Takeaways

- Affect regulation products the exhibit two main interaction modes: wrist-mounted or handheld/manipulable. We choose the latter.
- There is an opportunity to combine more than one feedback type in a singular product.
- Most highly dynamic and highly bio-enabled products are just research artifacts, not for sale.
- One main challenge is to design an object that supports frequent manipulation and contact while still occupying a "mindless" space.

5.3. Fidget Object Development and Aims

Prototype development, in the context of this project, serves to test our assumptions and accepted underlying principles. To accomplish this goal, we clearly outline the aims and approaches we used to structure the prototyping phase. It is worth nothing that this is a retrospective recreation of the process; like many design projects, the prototyping phase had its fair share of chaos and uncertainty. Even in that uncertainty, the goals, approach, and key aims should be clear and interrelated. The exact function and embodiment of the prototype itself is discussed in the "Prototype Construction" section of this chapter.

Affective Sensing and Interaction

One theory worth mentioning is that of "affective sensing," a subcomponent of the large field of "affective computing." This project is an exemplar of an affective computing device, specifically through the measurement of some personal data that reveals affect. As put eloquently by authors on the topic, "from the perspective of affective interaction, however, the goal is not necessarily to minimize the obtrusiveness but to design the technology so that the interaction becomes part of an affective experience" (Guribye et al., 2016, p. 1). Additionally, the goal of such an interaction is not to measure scientifically or derive objective data, but rather to allow a user to express and perceive affective sensation. That said, some authors believe the power of pervasive affective sensing will lie in its widespread use and that such large and diverse data sets will aid scientists and designers in understanding emotion and action in real-world contexts (Kanjo et al., 2015). For this project, we only wish to note that our fidget object seeks to operate in a "synchronous" sensing mode with elements of a passive (automatic) and active (intentional) system. This fits well with the need to navigate between implicit and explicit interaction based on the user's affective state.

Interaction Goals

Through our prior research, we understand some key goals that the prototype will be required to meet to work well as a fidget object that can aid in affect regulation.

First and foremost, an implicit interaction style is a necessary default mode to properly deploy an affective loop interaction. This project accepts the theoretical proposal of "unaware interaction" as a modification to affective loops and aims to split the difference between the two. The fidget object prototype should allow for a natural, implicit "fidgeting" interaction until the user exhibits behavioral indicators of excess stress and anxiety. At that point, the fidget object provides interactive feedback that draws attention to the user's affective state. The interaction thus becomes explicit and allows the user to reappraise their affective state and recenter on a productive mood. This switching between interaction modes will ideally reduce distraction from the fidget device in non-functional scenarios.

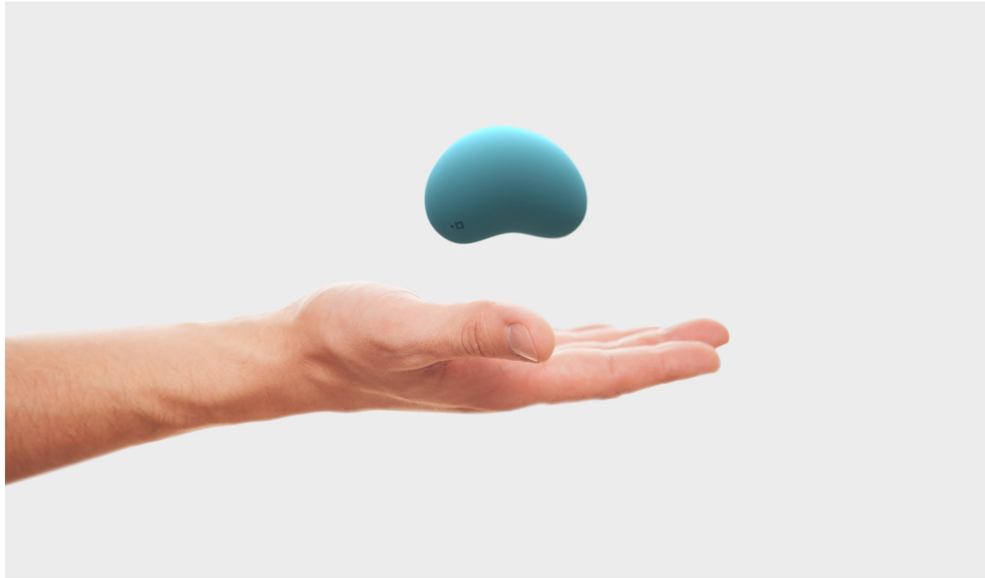


Figure 32. "Grasp" Platform for Affective Sensing. Grasp AS and Guribye, 2016

Most popular fidget objects are "non-smart" in that they are dead objects without any processing capability. Integrating hardware and software elements can allow for interpretative and freeform fidgeting within a singular device, better enabling situationally beneficial fidgeting. Importantly, we do not seek to produce a device with tens of different interactions, rather we wish to broaden one or two interactions to make them more engaging, dynamic, and communicative. Additionally, smart devices can produce a much wider and customized range of feedback than a static object. We have seen from our research that personalization and personal attachment are very important in long term use of a fidget object.

The prototyping conducted during this project is less concentrated on the core form or appearance of an ideal fidget object. Instead, we prioritize testing technology as applied to fidgeting situation and the ability to communicate affective state through interaction. Even still, we see the chosen prototype embodiment as meriting further development into a fully functional, self-contained prototype.

Requirements

Unlike many engineering-related design projects, we have no extensive "program of requirements" for this project. Given the research through design process, general aims need to be met, but specific requirements are developed from testing and further iteration. That said, we can list a few general yet important requirements for the concept in general:

> ***Technologically enabled and responsive:*** the prototype must be able to sense user input in some manner (preferably not biosensing) and respond to them. This requires some onboard processing.
>
> ***Mirror natural manner of use:*** the prototype should be as similar to existing fidget interactions as possible, and ideally the fact of being "smart" does not modify the interaction.
>
> ***Data Logging and Analysis:*** the concept should allow for later review of user interaction to help understand incidences of fidgeting.
>
> ***Form:*** The fidget object is to be of proper size to hold in one's hand, and also be pleasurable and desired in a tactile way.

These requirements are predominantly for the "envisioned concept" presented in the following chapter. However, they still direct and focus the prototype embodiment and design choices, alongside some critical assumptions of the project.

Critical Assumptions

While mentioned previously, it is valuable to restate the most critical assumption underpinning the prototype and envisioned concept. We expect that some amount of information on "arousal" dimension of affective state can be determined through a user's physical manipulation of a fidgeting object. For example, a more forceful manipulation of the object can signify increased arousal. This assumption is supported anecdotally from the RTA process, with one participant saying: *"People call it 'pen-spinning.' The speed of the spin is directly proportional to how stressed I am: increased stress = increased speed. And vice versa.. [P144]".*

We also assume that the actual, physical manipulation of a fidget object is relatively constant when a user is engaged in their focus task. If their attention is not on the fidget object or on mind wandering but rather on working, they will move the object in a very regular and repetitious way, thereby providing a baseline measurement for attributes of use like speed of rotation and acceleration in three-dimensional space.

It was a goal of the prototype to test this assumption (and iterate further based on results). Unfortunately, we were not able to conduct a suitable enough test to (in)validate this specific assumption. This is left as an opportunity for future development.

5.3.1. Early-Stage Concept Ideas

In deciding the form of the fidget object, we looked to analogous or already used products, for example pens, stress balls, worry stones, rosary beads, and more. A key aim was to leverage the form and understanding of preexisting product. This eliminates the need for a new "mental model" and lowers barriers to adoption. We also chose to avoid creating a pen, as Dr. Alonso had spent his PhD

working on such a device, and we seek to push knowledge into new spaces. While there is much power in adapting an object that is instrumental to on-task work, we desire to create a separate, distinct "fidget object."

Initial sketches and prototyping highlighted three potential products and known forms: First, worry stones inspired a large footprint worry stone with rotating ring that was prototyped with fuse deposition modeling (FDM) 3D printing. This direction ended up being an unsuitable hybrid of forms that was not ergonomic or clearly manipulable, so it was not pursued further in prototyping.

Next, we considered a range of soft and squishy devices like stress balls to inspire a "responsive" version of similar shape and size. Ideally, this "responsive" stress ball could standalone and measure squeezing forces like the Grasp stone project (Guribye et al., 2016). It would further be responsive to one's applied force, providing force feedback upon squeezing. Our prototype used a non-Newtonian fluid interior: as one squeezed harder an moved the liquid quicker, the fluid became more viscous and resisted the squeezing force.

Figure 33. Early Concept Ideation Sketches

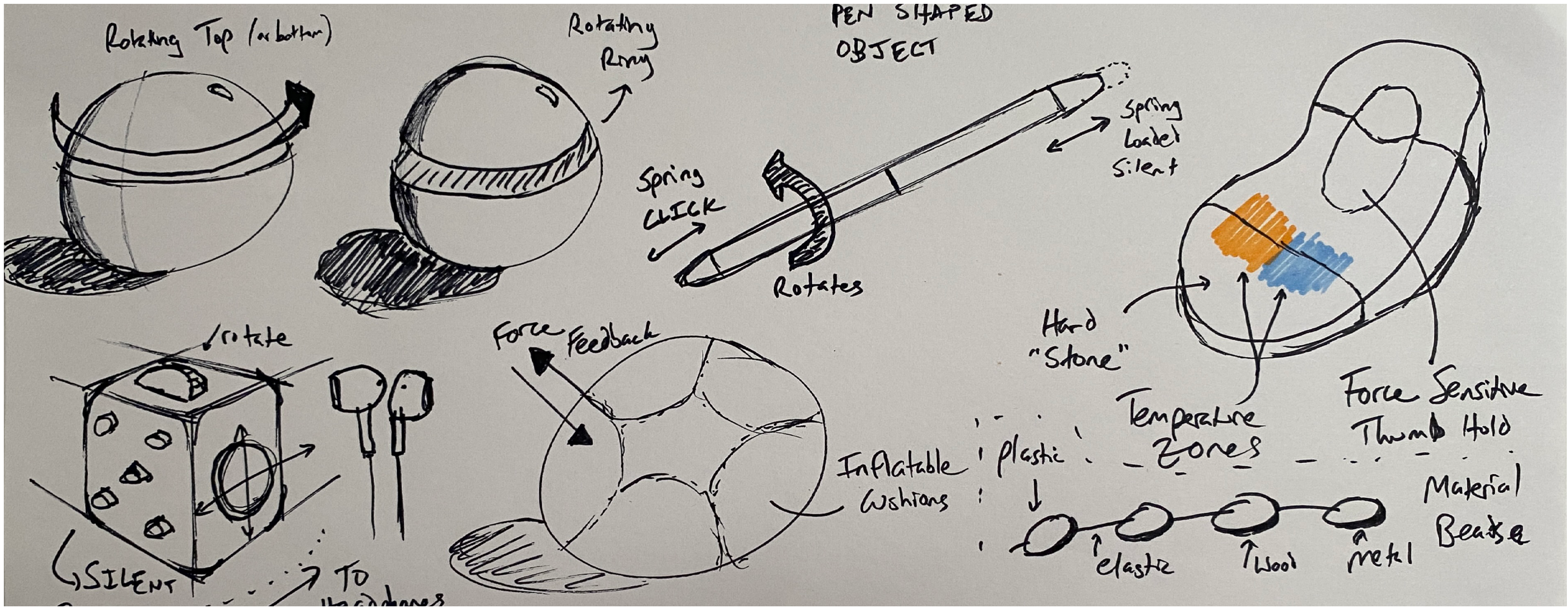


Figure 34. Baoding Balls

Most promising of all three was a set of two spheres in the general form of Baoding balls, 保定健身球 in Chinese script. Baoding balls, or Chinese meditation balls, are a traditional object in Chinese culture (Figure 34). They are manipulated two to a hand and rotated around each other with a goal of creating smooth motion. A marble or other hard object within creates a ringing sound that is correlated with the movement of the balls. Often used by the elderly, manipulation of Baoding balls can represent one's functional abilities and motor skills. While they are not explicitly a "fidget object," one could describe the use behavior and circumstance as very similar to fidgeting.

For future concept development, we selected the Baoding balls direction. This choice was largely motivated by the proper size for fidgeting, the clear conceptual model for use, their ability to stand alone (untethered to a larger system), simple and repetitious interaction, and because a simple sphere is a very flexible platform for integrating new kinds of sensing and feedback. This selection was conducted without any strict "tables of requirements" or evaluation matrices. While many projects can use those decision criteria and methods to great effect, this exploratory Research-through-Design process is less suited to those rigid methods. The most important thing is not to have the most perfect initial concept, but rather a good foundational basis upon which to test and iterate, which we achieve through this concept direction.

5.3.2. Selected Concept Direction – "Fidget Spheres"

Approach

Creating a complex and interactive fidget object is challenging to manage all at once. Progress in this project stalled out as the author struggled to make headway tackling all directions at once. The development approach was changed to make small stepwise gains in prototype functionality in shorter timeframes, in a "design sprint" style approach. Specifically, the focus on "miniaturization" was removed to allow technology validation on an easier-to-produce larger scale. Electronics were prototyped in breadboards before moving to soldering and smaller components, and each component was tested separately before uniting in a system.

Form and function were split into two distinct branches of development in the prototyping stage. Similar to the issue of miniaturization, doing both at once in a united product would have overcomplicated the process. We detail developments in each branch below.

Form

The general form of a Baoding ball is rather fixed, as a clean sphere is necessary for proper movement and rotation. However, the size of the ball can range from a diameter of around 35mm up to 100mm depending on the context. We quickly produced balls of 35, 40, 45, and 50mm diameters to evaluate which was most suitable for our use (Figure 35). The author and advisory team selected 45mm as the biggest size that was still functional. More internal volume will aid in later high-fidelity prototyping, so we sought to maximize it. A future project could test the size with a larger and more diverse user population to understand appropriate

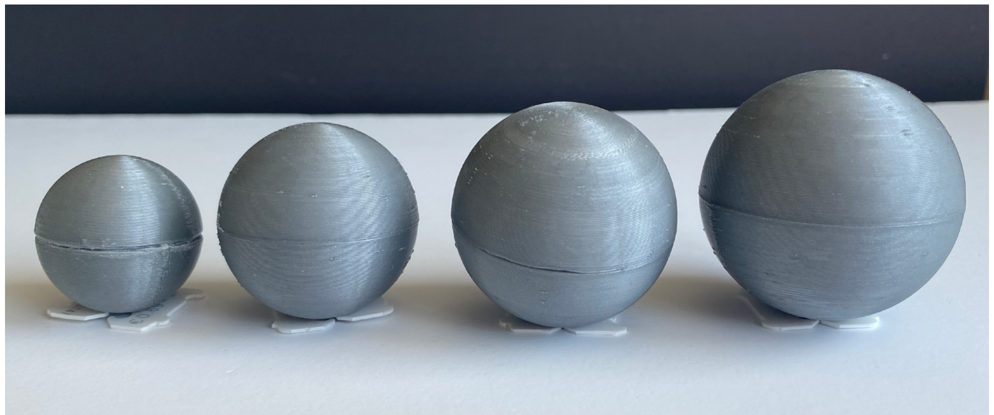


Figure 35. Trials of Ball Form Diameter

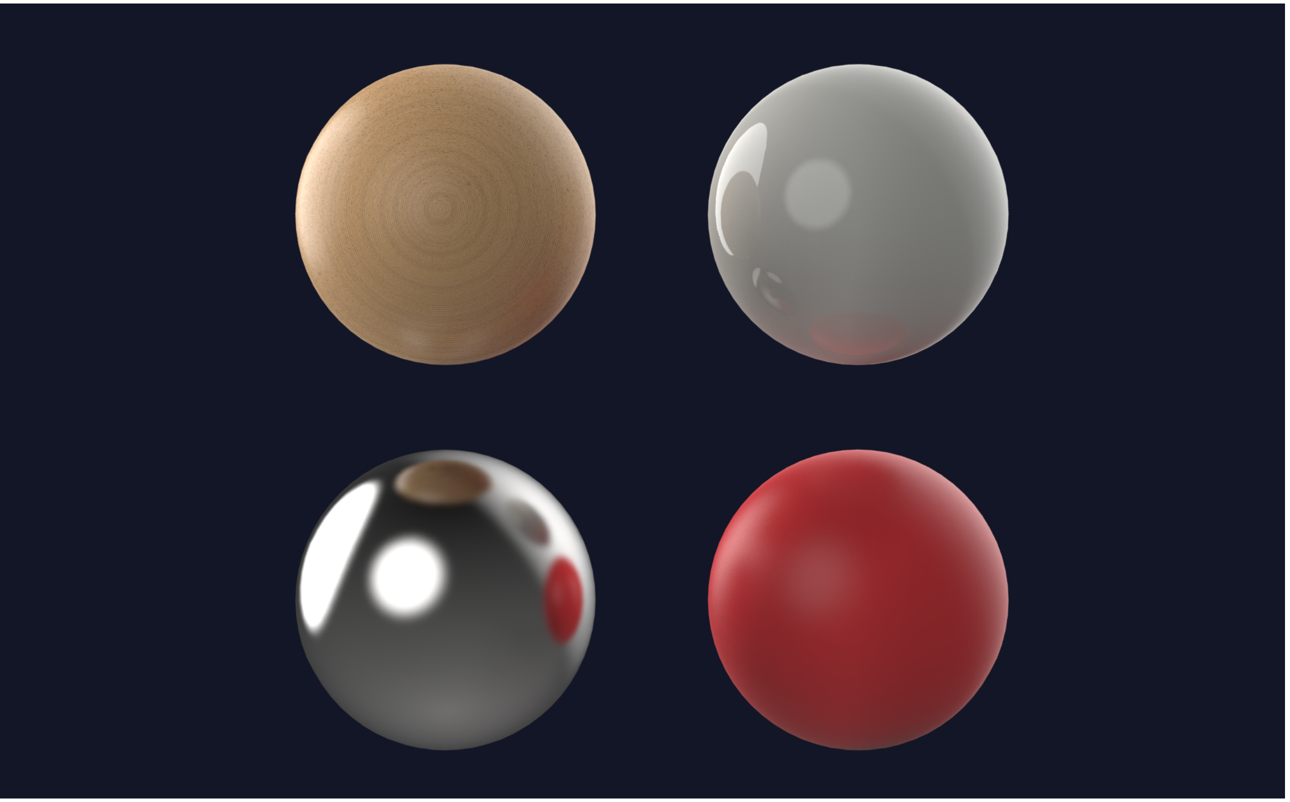


Figure 36. Fidget Spheres Materialzation Render

maximum and minimum diameters.

While traditional Baoding balls are an uninterrupted sphere, we see high value in integrating a spinning element, either a sort of "orbital" ring or a ball that rotates on itself. We prototyped a few different shapes and surface textures of a spinning ring placed in the middle of the fidget object to see how it impacted the overall use of the product. Generally, the ring must be quite flush to the sphere surface, and any textural elements that are too severe will catch the second ball and inhibit smooth manipulation in one hand.

Material

Baoding balls are normally constructed of a "cool" material such as stone, metal or ceramic with an ornamental surface design on higher end products. We wish to remove the device slightly from its culture of origin, and instead propose a mixed material ball made of metal or metal-reinforced plastic on one half and wood on the second half. Our research demonstrated that these "cooler" materials are perceived as calming and benefit regulation of high arousal affective states more than warm or hot objects (Salminen et al., 2013; Umair, Sas, et al., 2021; Wilson et al., 2016). Ceramic may be at risk of breaking in our use context and is therefore not suitable.

Prototyping spheres of these materials is time consuming, so the array of materials is represented in the render of Figure 36. A "looks-like" prototype of the envisioned concept has been created from aluminum and can be seen in the next chapter.

Interaction

The majority of our time in prototype development was focused on translating desired fidgeting interactions into a product and associated prototype. The following are the interactions selected alongside a brief justification.

Spinning rings – spinning a ring around a stationary axis was the most common manifestation of fidgeting in our data and spinning a pen in one's hand (what we are calling "twirling," or rotating on a non-stationary axis) was also exceedingly common. Therefore, it reasons that inclusion of this movement will appeal to a

Figure 37. Spinning Ring Prototype with ABEC Bearing

large cross section of users. Further, analyzing the applied force on a rotating ring could lead us to behavioral insights and information on affective state. This is further explained in the envisioned concept.

The basics of a spinning ring were implemented in our early, non-smart prototypes through use of a low cost ABEC 3 skateboard wheel bearing force fit into a 3D printed component (Figure 37). While not able to capture data, we did confirm that the integration of a spinning ring into a sphere was still understandable and pleasurable in interaction.

Next, “squeezing” interactions are very frequent, especially when the fidget object is soft and malleable. This interaction is especially common in children, with 89% of one study population exhibiting the behavior (da Câmara et al., 2018). Further, squeezing was more frequent in moments of anger and frustration, suggesting a link between grip force and the (negative) valence of an emotion. We can again leverage this physical manifestation of affective state to direct appropriate feedback through the fidget spheres.

5

Separate from spinning is “rotating,” when two or more object and rotated around each other. This is the default use mode for Baoding balls, and as such we design our product to also support such an interaction. As the two balls make contact and rub against each other, we expect that this motion can be recorded and analyzed to evaluate the smoothness of motion. We can then use this smoothness as an indicator of affective state.

This is very similar to one operating principle of the Mindspheres (Figure 38) speculative project from Philips, stated as “build(ing) upon the interplay between our state of mind and our bodily activity” (Djajadiningrat et al., 2008, p. 96). This project is a key inspiration to this master’s thesis, despite key differences in intent. The creators envisioned Mindspheres to be used as a “challenging and playful” focus task to enter a relaxed state of relaxation, and reference mindfulness meditation frequently. Importantly, the Mindspheres were monomodal in their data collection and mapping to haptic feedback. They operated with constant (explicit) feedback to inform the user of the way in which they manipulated the objects. We aim to only use sparing feedback and allow the interaction to proceed as “unconsciously” as possible. The Mindspheres additionally leverage visual color change, a feedback modality we excluded due to its incompatibility with an unaware interaction mode.

Figure 38. Philips Mindspheres Speculative Product. Djajadiningrat et al., 2008

Above all, we wish to capture some sort of data from these interactions and use it to provide feedback that can modify one’s affective state. This is in line with the affective loop and “unaware interaction” concepts discussed in the literature review earlier in this report. The exact categorization of the interaction is therefore not critical to the project, but it does help to organize our investigations and set actionable goals.

We also acknowledge that there are many ways of fidgeting, and not all preferred ones will be covered in these interactions, especially for those who are constructive or destructive fidgeters. It is our position that it is better to concentrate on a limited range of interaction and optimize that than to cast a broad net over too many interaction modes.

Technology

To capture one’s interaction with the fidget spheres, we require a specific array of technology that is largely available in modern electronics. The exact models of the devices chosen (name and specification) are detailed in the “Prototype Construction” section, but here we motivate their use.

To determine relative position and movement velocities, we use a 6-axis IMU (inertial measurement unit) which can determine the rotation velocity in 3-dimensional space and the force of gravity due to acceleration in 3 axes, which is translatable to orientation. Importantly, all these measurements are relative to an initial reference frame, and IMUs tend to have large “accumulated error,” especially cheap ones. IMUs conduct integration equations to derive velocity and position from acceleration, so measurement errors build over time and then the IMU experiences “drift” of calculated position relative to actual position. Even still, our applications are not so hypersensitive that we need to worry about this too much, and positional location in a 3D space is not critical.

In order to capture squeezing forces, we utilize a basic force-sensitive resistor. Other sensors like strain and flex gauges would also work, but a FSR works for our context as it is relatively stable when mounted well and quite cost effective. Vibration feedback is given through ERM or LRA type haptic motors. Other types exist, including voice coils, but these two best suited our context and use cases.

Future iterations of the device could add in biosensing as another data stream and to cross-reference other results. As detailed earlier, PPG sensors can detect heart rate variation (HRV) and give an indicator of state of arousal, and skin conductivity (galvanic skin response or GSR) is also a useful measure. If time and cost allow it, future projects would be wise to integrate these sensors and conduct experiments to link biological data with physical expressions of affect.

5.4. Prototype Components

While each component was built up in a piecewise manner, the first united prototype was a long process and necessitated a few iterations and small changes. To best test isolated interactions, one prototype allowed for squeezing interaction and another for motion and rotation actions. Together, these cover our two most applicable interaction modes. Unfortunately, each prototype was not converted to a fully self-contained or wireless version as we did not have appropriate batteries available at the time of prototyping (and this would have required further time investment). The following sections describe the components used and the main modifications or customizations done to suit our use context.

Physical

Both prototypes used a 3D printed shell in PLA due to the ease of manufacturing and iterative changes and development. This means the textural and material interaction as not fully representative of the intended product, but it was sufficient for early testing. The later “looks like” prototype remedies this issue. Figure 39, below, shows the squeeze feedback ball which utilizes a ERM vibration motor.

In future developments, we hope to add a desired material (metal, wood, etc.) one at a time and see how these changes alter one’s perception of the vibration feedback. As Giaccardi and Karana note, “experiential qualities of materials are not fixed” and vary based on use case and scenario (Giaccardi & Karana, 2015). Therefore, we must test both the feedback independently as well as feedback mediated through a desired material to confirm alignment.

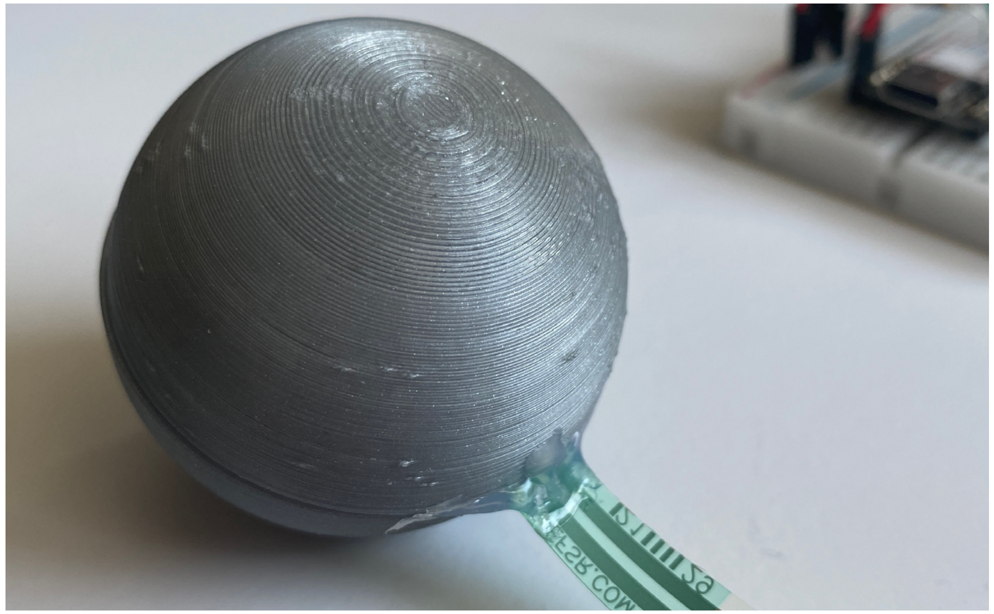


Figure 39. PLA 3D Printed Shell of Prototype Fidget Sphere

Hardware – Microprocessors

Most consumer goods will utilize custom printed circuit boards (PCBs), especially when there are strict packaging constraints or technical requirements. Designing and producing a custom PCB is far beyond the scope of this project, and as such, we needed to identify the most suitable mini form factor programmable microcontroller for the fidget spheres. Further, it was desired that these microcontrollers could be programmed via the Arduino IDE, as the author has experience in this environment.

Key requirements include Bluetooth or other wireless communication, +5v power rail, I2C communication protocol, PWM digital output pins, and preferrable an onboard 6 axis IMU. The optimal choice was then to use a Seeed Studio Xiao board, specifically the Xiao BLE Sense (Figure 40), which adds Bluetooth and a 6-axis IMU to a 32bit SAMD21-type processor of the ARM® Cortex®-M0+ family.

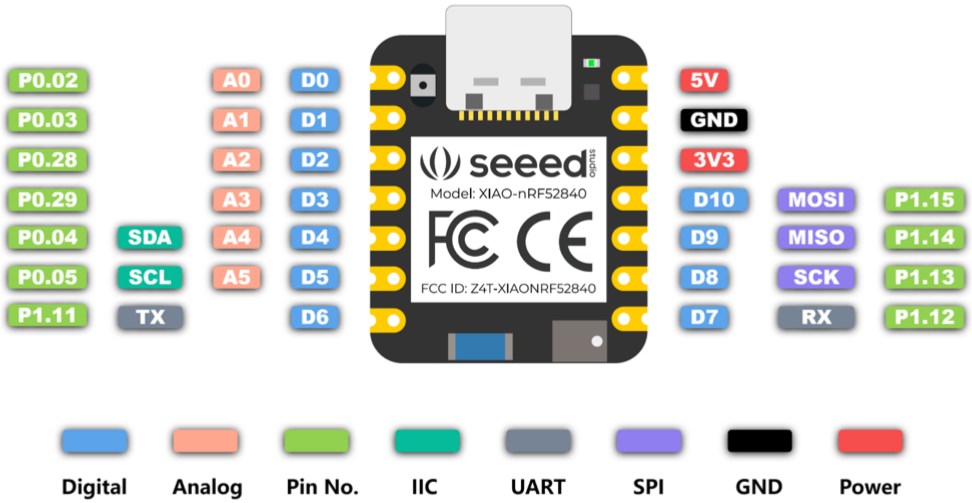


Figure 40. Seeeduino Xiao BLE Sense Sketch and Pinout. From Seeed Studio

Regardless of the technical specifications, we found the right board for this application (at least in the development stages). Were this product to be sent to market, it would require a custom PCB and likely significantly less processing power and additional features.

Hardware - Vibration Motors (LRA/ERM)

One of the key decisions for our interactive product is which type of vibration motor to use. ERM (eccentric rotating mass) motors are cheap and a long-standing component, where LRA (linear resonant actuators) are newer and arguably more precise. For the purposes of testing, the force-sensitive ball prototype had an ERM motor, while the rotation ball had a LRA motor (Figure 41). Feedback from the initial user test suggested a preference for the LRA due to less unintentional noise generation.

The motors we selected ran maximally at +5 volts and approximately 100mA of

current. We propose that future prototypes use vibration motors capable of higher current draw, not to explicitly make the maximum force higher, but rather to allow for a more distinguishable range of feedback patterns.

Other vibration feedback motors exist on the market like voice coils, but for the first stages of prototyping and small scale of final product, these two versions were seen as most optimal due to size, power requirements, and cost. The cheap motors experienced multiple breaks in their wires, so for future we will consider buying more robust motors. Driving these (and other) haptic motors is not always simple, so we added a component to do so.

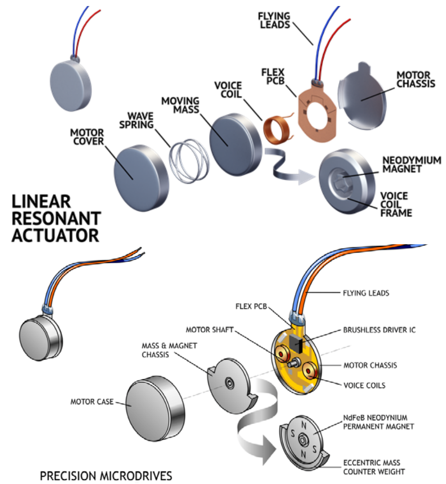


Figure 41. LRA and ERM Motors. From TI and PMD

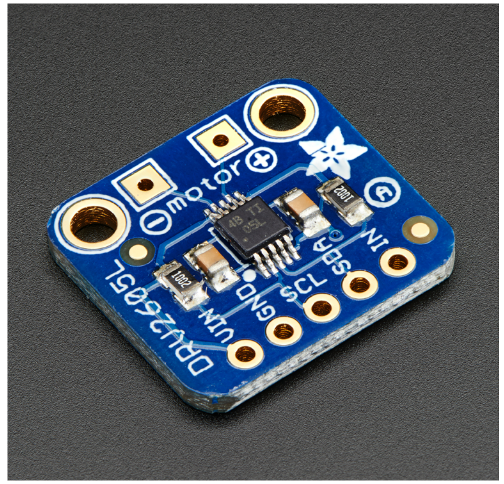


Figure 42. DRV2605 Breakout Board, From Adafruit

Hardware - Motor Driver Boards

To quickly prototype different feedback patterns and intensities, as well as to have an appropriate power driver, we selected the DRV2605 chip from Texas instruments. Specifically, we purchased the Adafruit breakout board version which allowed for more rapid prototyping (Figure 42). The DRV2605 is designed specifically to drive both ERM and LRA haptic motors over I2C connection at a maximum of 5.5 volts. It also includes lots of nifty devices like “automatic resonance tracking” for LRA motors, automatic braking, level calibration, and PWM control. Perhaps most important is the built-in library of haptic effects that can be looped and triggered via software. These effects were critical for rapid discovery of what “feels good” or “makes sense” in terms of vibration feedback. For a commercial version of our fidget spheres, we would be required to license this effects library from Texas Instruments, or forgo it’s use and design our own haptic patterns.

The motor driver and motor combinations were first tested on breadboards outside of the fidget sphere itself to verify proper soldering and haptic feedback. We found that the feedback from the haptic motor felt very different depending on whether it was mounting in the sphere or simply freestanding, which further confirms the importance of material on haptic perception.

Hardware – Force Sensitive Resistor (FSR)

To detect squeezing and exerted force on the prototype, we utilize a force sensitive resistor (FSR). A FSR is a sandwich of conductive and non-conductive components that, when compressed, decreases resistance from over 1 megaohm down to practically 0 ohms. Not all FSRs exhibit a linear relationship of force to resistance, but some can. We utilize a very basic FSR402 sold by Kiwi Electronics and manufactured by Interlink Electronics (Figure 43). It is a circle shape with an active area of approximately 15mm.

There are many ways to measure applied force, including detecting flex or strain, through a more sophisticated load cell, or even the diffraction of light through deformed slits. However, for our application which requires relatively low precision and repeatability, a standard FSR is suitable.

5

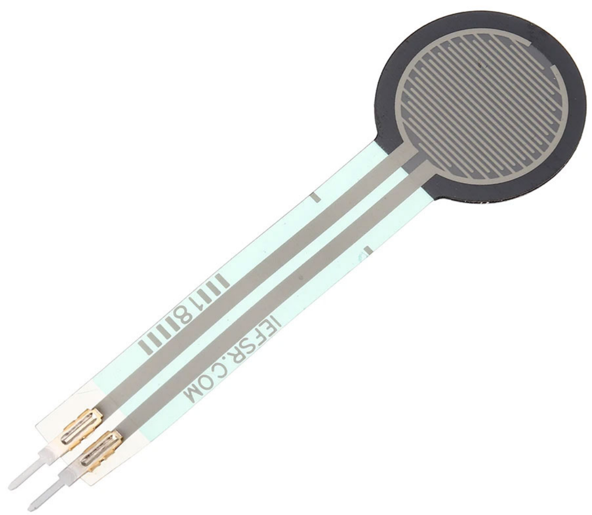


Figure 43. KIWI Brand Force Sensitive Resistor. From Kiwi.nl

In the prototyping phase, it was quite difficult to "tune" the resistor to operate within an appropriate current range, and multiple additional resistors were tested before settling 430 ohms total. Around 500 ohms of added resistance is likely the sweet spot, but we did not have those resistors available.

Software – Arduino

Programming was done in the Arduino IDE (integrated development environment) using native Arduino language, which is largely based in C++. The included drivers and PCBs are depended on their own libraries of functions and firmware. These libraries are provided by the manufacturers and downloaded from the internet.

The complete programs for the squeeze and rotation prototypes are included in Appendix F. While adapted for our purposes, these programs are derived from the supplied example programs included in device driver libraries and other examples across GitHub and the web.

The author could spend time in this section detailing all of the trials and tribulations of programming these fidget spheres prototypes but believes this would not serve any clear purpose. In this specific instance, the amount of time spent on the work does not directly translate to the space used in the report.

United Prototypes

Our prototypes as used for evaluation were wired to a microcontroller external to the fidget spheres themselves. Each prototype interaction has its own board as to make testing a bit easier, but one can clearly see we are still constrained by wire length and quantity (Figure 44 and Figure 45). Next steps will have to include the integration of all components within the same casing.

Conclusions

The construction of the prototype took more time than expected and required more disparate parts than originally intended. Further, it was very difficult to produce anything capable of "testing" or "evaluation" until it was all combined into a representative prototype. In the future, we would benefit from a better structured system to receive feedback on design choices before they are implemented, and that time investment is made.

Despite the obstacles, the prototype met all key goals for our first functional prototype and exceeded reliability expectations after some early breaks and faults. It functioned well in the workshop-style evaluation session and garnered clear and critical feedback to inform a next generation. We recognize a need for a further prototype that more closely simulates the envisioned concept, which we can then

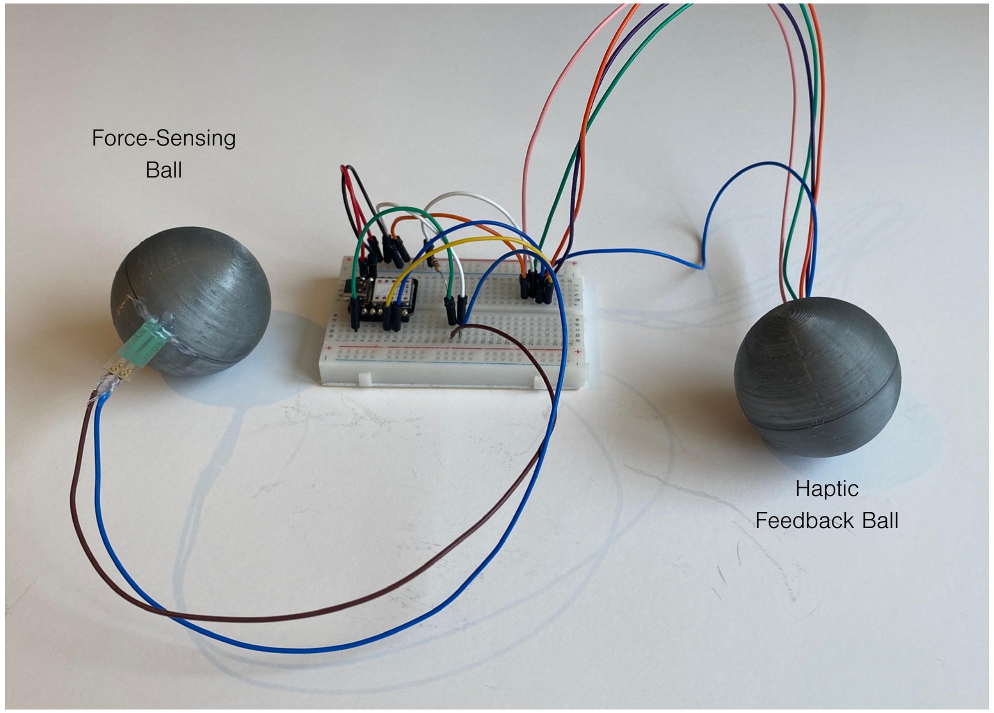


Figure 44. Force Sensing Prototype Assembly, own image

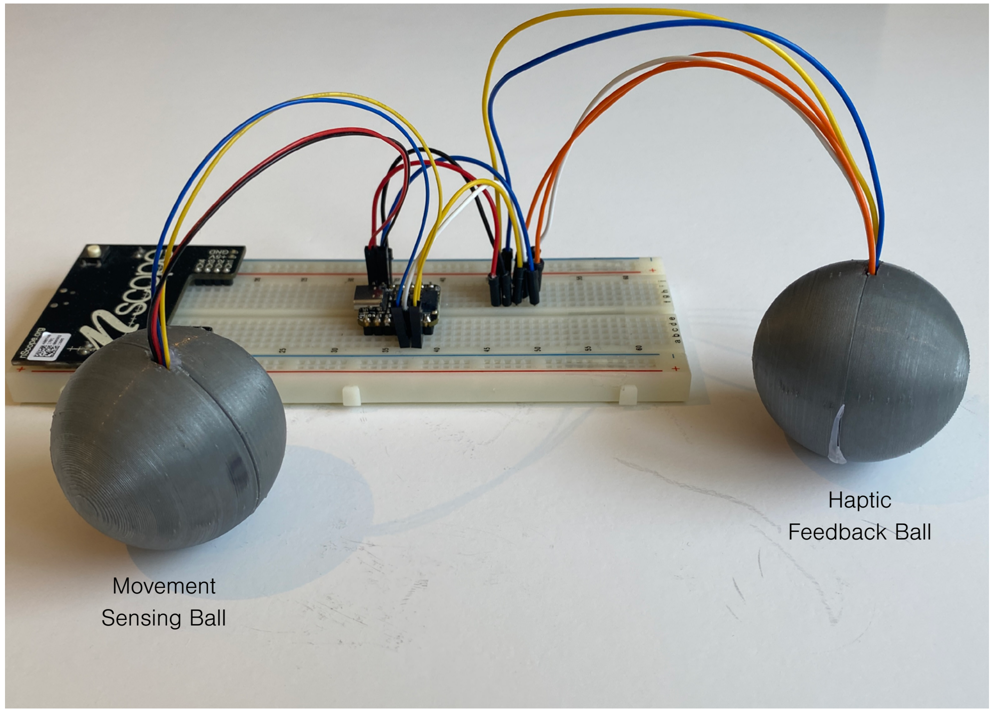


Figure 45. Rotation/Movement Prototype Assembly

5

use to test the device in a representative environment and over a longer window of time.

5.5. Evaluation – Workshop Session

After validating the security of the electronic hardware and ongoing function of the fidget object prototype, a workshop was schedule to receive feedback from a representative user population and further direct the final developments in the project. As the prototype had only been shared amongst the author and supervisory team, it was time to present it to external parties.

Structure

Six masters' students at the IDE faculty were recruited for a one-hour workshop that took place on 16 June 2022. The workshop was facilitated by the author and concerned evaluating perception of the two interactive fidget object prototypes, as well as a generative "breaching" session. The workshop followed a strict time schedule as follows:

16:00 – Open workshop with explanation of project, use context, fidgeting definition.

16:05 – Participants share, explain their preferred fidget object (that they brought from home).

16:20 – Split in 2 groups of 3, begin prototype evaluation sessions and Breaching exercise.

16:35 – Switch activities with group, each group has equal time per activity.

16:50 – Plenary/group discussion on opinions of prototype, project, other thoughts

17:00 – End (and give out banana bread!)

Execution

The prototype evaluation sessions were conducted in a mostly free exploration manner, with participants allowed to play with each device however they pleased. About halfway through the group's time, the researcher revealed exactly what mechanism provided feedback such that the participants can reset their mental models and continue to gain new impressions. All thoughts were recorded on sticky notes by the participants and placed on a preprinted worksheet. Digitized versions of the worksheets are available in Appendix G.

“Breaching” is an experimental activity mostly used in the context of sociological research whereby participants are asked to violate (or encounter a violation) of accepted social norms. The basic assumption for this method is that social norms exist within a culture, and even more, those norms are upheld by people who accept them and participate in that society. To become consciously aware of those norms and challenge them can be difficult or shocking.

In the design context, participants in the evaluation workshop were asked to consider “what characteristics of a fidget object would violate social norms” in our two main use cases: an in-person meeting or presentation, and an online video lecture or presentation. Once they decided what those characteristics were, they were asked to define the social norm it would violate. The main goal of this exercise is to come up with the Worst Possible design idea, and later for the author to invert these results to understand what traits a fidget object would be required to have to well fit the use context. Worst Possible Idea is a known ideation strategy, generally used as an icebreaker in generative session, so the breaching approach was our version of this general concept. As with the other exercise, the breaching worksheets used can be found in Appendix H.

Figure 46. Workshop Session In Action, own image

Results - Breaching

As mentioned previously, the workshop marked the first time that external parties had used the prototype fidget objects. As expected, feedback was critical and highlighted some key inconsistencies in the device. We first address the learnings from the breaching exercise, and then the prototype evaluation itself.
Participants highlighted the importance of “the appearance of attention” in online video meetings, as it denoted respect for the speaker and circumstance.
As such, the ideal fidget object should not present a visual distraction in the environment of a video meeting participant, even if based on the computer screen itself (as those changes in light/color can be seen reflected in participants’ faces).

Figure 47. Paying Attention. From Julia de Boer/The Next Web

Next, certain actions and interaction, for example, forceful leg bouncing. seem to exude an “anxious” energy when observed by another party. Obviously, these sorts of motor expressions are to be avoided if possible. Participants also considered sensory associations with organic or biological things (e.g. the buzz of a fly or smell of a wet dog) to be at odds with the proposed use context. Some felt the vibration feedback of the prototypes produced an audible tone that mirrored that of a bee, and this made them uncomfortable.

Lastly, and importantly, the local cultural understanding of a behavior will strongly influence the acceptance of a fidget object if it produces that specific behavior. For example, leg bouncing has strong cultural stigma in Korea and Japan (Koreans believe you “lose your luck” when you shake your leg and Japanese often say leg shaking is “something a poor person does” and is called “bimbo yusuri” [貧乏ゆすり]). Our designed fidget object should carefully consider the use culture alongside the context to avoid reproducing stigmatized behaviors. These results from the breaching session help to inform the next iteration of prototype and the idealized future vision.

Results – Evaluation

Most participants exhibited a fascination for the prototype fidget objects, also describing strong emotion elicitation due to their interaction with the device. While this is quite interesting to note, eliciting strong emotion was not necessarily the goal. In fact, it was clear that the fidget object falls on wrong side of “unconscious/conscious” barrier (or implicit/explicit interaction divide) as too much concentration was used in interacting with the product and it became a central focus. Some of this effect, however, might be due to the setting and context of the research and novelty of the device, so we need to test again in a representative use scenario when possible.

5

Participants felt the force-sensitive prototype was pushing them to be aggressive and squeeze harder and harder. They linked the vibration feedback as an expression of “suffering” on behalf of the device in an anthropomorphic way. This elicitation of aggression and force is opposite what we aim to accomplish.

One participant said the prototypes gave “sex toy vibes” due to the sound and feel of the vibration feedback, as well as the plastic material. This was especially prominent with the rotation-based prototype which uses an ERM vibration motor. Another participant compared the unintended audio feedback to “like a dying frog” and confirmed that made them uncomfortable.

On the software side, participants found the small delays in feedback response to be very apparent and alienating, i.e., it drew them out of the moment and interaction in a negative way. This surfaces a very interest challenge: to solve this disassociation, should the feedback be as immediate as possible? Or should it be even more delayed and averaged over time? Participants also disliked the static preprogrammed feedback patterns when hitting the upper force and rotation limits on each respective prototype. They found it boring and not intriguing enough given the dynamic nature of the prototype until that moment. An interesting question is now how to provide feedback with the same meaning (maximum force/speed reached) while varying the manifestation of that feedback enough to avoid boredom.

On the physical embodiment, multiple participants wished that the prototype was untethered from wires and that a ball was used for both sensing and actuating feedback. They felt their experience would have been more representative in this instance. They also noted that it required two hands to fidget (at this moment) and that is perceived as a negative trait as it limits the use scenarios of the device.

As a positive note, both devices did elicit a lot of playfulness from participants, with some even staying after the workshop to continue playing with it. The above list of feedback does not include all the small elements they liked, but rather just the most glaring issues. Overall impressions were positive and especially curious, as the whole group was now aware of their fidgeting habits.

Next Steps

The workshop was clearly a valuable use of time as the feedback can help to critically direct the future embodiments of the fidget object. It was also made clear that the effect on affect will not be easily measurable, and even further, will only be worth measuring if the device is used in the proper context. We can clearly see where the implementation missed the mark (e.g. inspiring anger through squeezing) and change these elements, but it is not yet certain how much positive change the device can generate in moving users towards a “productive” affective state in their work environment.

This is a very similar challenge faced by Dr. Alonso in his PhD work with the Relax! Pen (Alonso et al., 2008; Bruns Alonso et al., 2013). Determining the exact affective impacts of his interactive pen was challenging and even inconclusive, and we foresee the same for the prototype fidget object.

Originally, the project was to conduct one more evaluation of the prototype before finishing: an intensive observation of the fidget object in use during a participant’s normal daily work meetings and tasks. Ideally the prototype would be refined before this moment, and after the green light meeting, the test can be executed and analyzed. Unfortunately, time ran out after the green light meeting, and the test was not possible. The experiment would have provided the last bit of data needed to inform our final concept, user journey and scenario, and features that need modified, improved, or removed. However, even without such a test, we can be reasonably confident that we are still developing in the right direction.

6. Envisioned Final Concept

The prototyping phase of this project was key to understanding what changes and developments need to be made into the future. It also revealed the immediate challenges of producing a small and interactive object with conventional design prototyping skills and limited time. The lower fidelity of the prototype is therefore not fully representative of the design concept or all the desired features. In this chapter, we detail that envisioned final concept through text description and sets of 3D renders. We also recognize that “final” may not be so final, as all concepts can be further iterated. This is final in that it marks the end deliverable of this project, and not the last evolution this product may see.

The envisioned Fidget Spheres concept addresses the critical interaction goals and requirements laid out in the concept development section of this report. The concept itself was not created in real life due to the outsize time investment that would require, but it has been digitally rendered. Further, we created a dimensionally accurate model in Solidworks to enable future 3D printing of internal support structures and creation of technical drawings. A separate “looks-like” prototype was manufactured for use in the showcase video (and for fidgeting, of course!)

Ideal Interactions

To review, the Fidget Spheres have a specified desired interaction set and behavioral pattern. This is largely similar to what was detailed before, so we summarize below.

The device rests in an accessible and relatively fixed position and is always ready for use, without need for start up or ancillary programs. Normally, the device acts as a plain, non-technologically enabled fidget device, allowing the full range of standard fidgeting. The spheres capture physical expressions of affect through movement, namely the translation and rotation of the sphere itself alongside the rotational velocity of the middle ring. Additionally, a squeeze force can be measure on each of the two spheres. Feedback is predominantly given through vibration, modulating both severity and pattern to become more or less noticeable. Additionally, the ring can provide force feedback as explained in the following section on the Smart Knob project.

The device also logs these expressive physical movements and gives them a time stamp, allowing for retrospective analysis of the moments in which a user was unfocused and left a productive mood state. The future Fidget Spheres can also link with one's schedule from Outlook and become "awake" at the start of intensive meetings, inviting the user to utilize them in an ongoing manner to maintain a productive mood state in that meeting.

These interactions continue the goal of producing an implicit interaction that can float between unaware and aware depending on the function. We are unaware of the interaction and feedback when fidgeting calmly and while productive. The feedback becomes noticeable i.e., aware, when our interaction expresses a detrimental change in affective state.

Figure 48. SmartKnob. From ScottBez1

Implementing 'The Smart Knob' In Context

The Fidget Spheres contain a spinning ring in the middle of each sphere. The ring or wheel is free spinning in its default state. Overly forceful interaction will cause motor-generated resistance, or force feedback, to build over time, and specific digital detent patterns can be generated to bring awareness to one's

fidgeting behavior. While this interaction concept was generated during ideation, we later discovered a novel project that creates these exact desired interactions in a standalone control knob.

The "SmartKnob" haptic knob is a project by internet denizen "scottbez1," who appears to be a hobbyist electronics designer and tinkerer. He has created a knob with unlimited rotation based around a brushless gimbal motor. This knob can simulate "virtual detents" of any programmed pattern, force, or other specification (Figure 48). Additionally, the knob can spin freely with minimal rotation or feeling of notches ("cogging" in electronic motor terms). His SmartKnob also contains a display and PCB strain/flex detection, neither of which would be relevant in this envisioned concept. The GitHub page for the project (https://github.com/scottbez1/smartknob) contains detailed documentation, component recommendations, PCB schematics, and more.

The smart knob is missing one critical feature, however, and that is inertia. Once force is no longer applied, the knob stops immediately. For the Fidget Sphere to have a free spinning ring, we would have to calculate and simulate inertial movement for the ring based on user input. While this is possible, it has not yet been implemented.

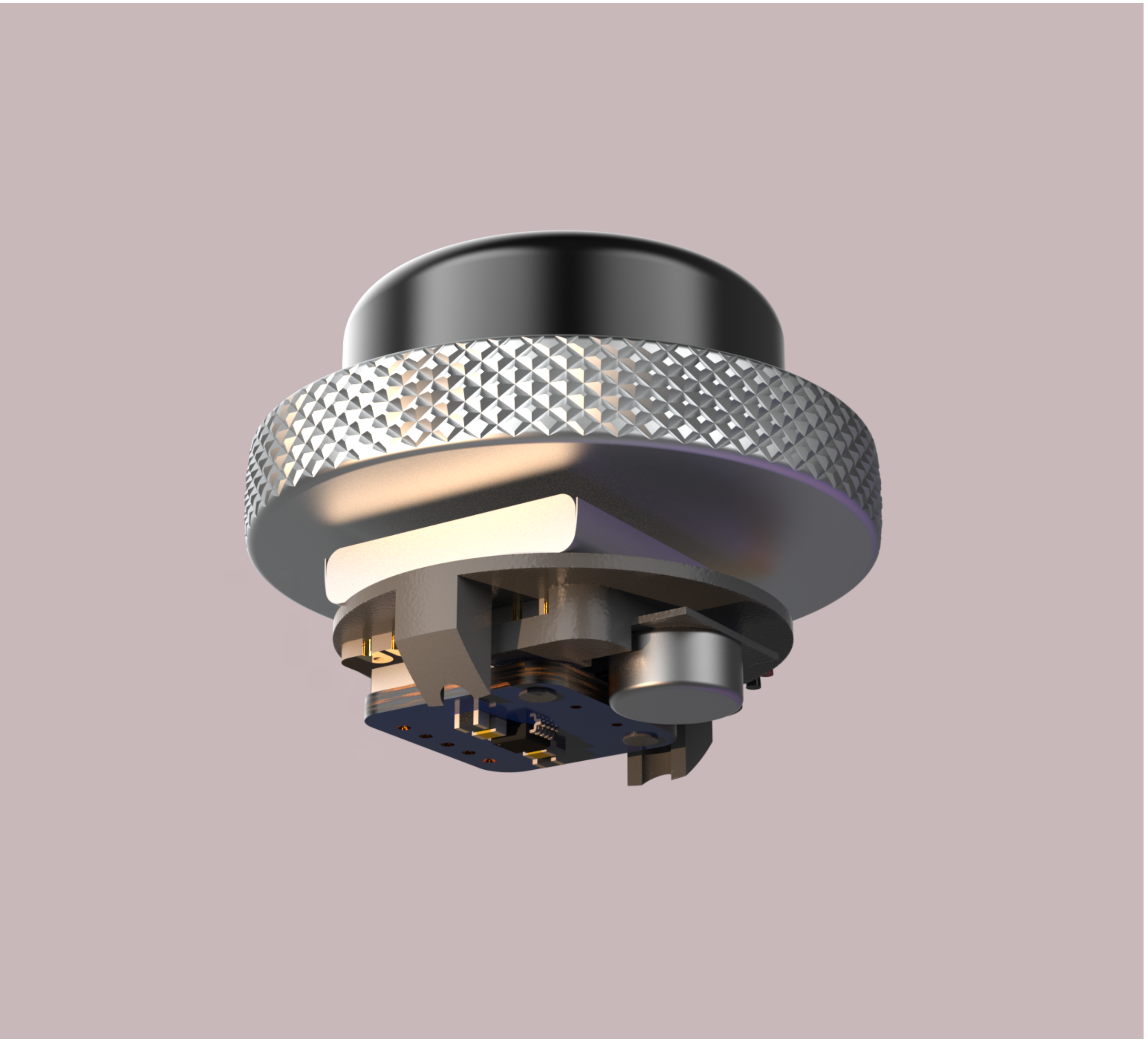
One of this author's larger frustrations during this graduation project is his inability to construct a version of this SmartKnob within the 100-day span. It so very clearly represents a dynamic and engaging mode of interaction that can be easily translated into the domain of fidgeting and feedback, specifically into our "rotating ring." By creating variable detents and force feedback within the ring, we can very intimately embody an affective loop experience that is highly responsive and communicative. Physical movement adds an extra dimension of feedback on top of haptic vibration patterns already embodied in the device.

While this specific feature and feedback mechanism has not been tested in the context of this project, we feel strongly enough of its suitability that we are including it as a component of the envisioned final concept. As stated before, these features will need to be built and validated to truly declare the Fidget Spheres as a functional product for affect regulation and encouraging a productive mood.

6.1. Rendered Prototype

In order to “bring to life” the envisioned concept, the entire system was designed, modelled in 3D, and then rendered. The following renders show both the internal and external features of the Fidget Spheres. For a more “in action” understanding of product usage, please see the showcase video available on the TU Delft Repository.

Figure 49. Internal Electronics and Components of Fidget Sphere, own image.



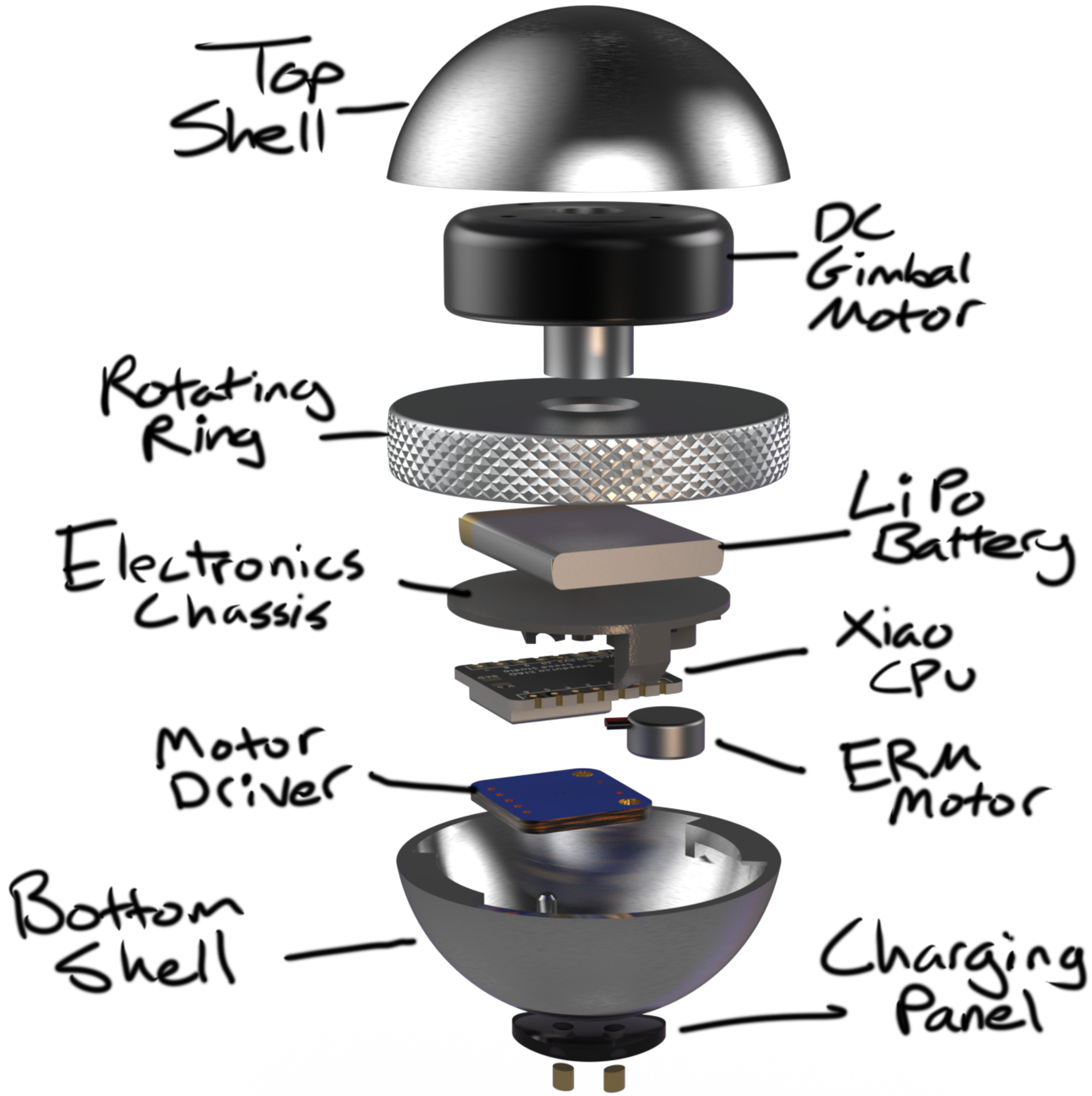


Figure 50. Labelled Exploded View of Fidget Sphere, own image.

6

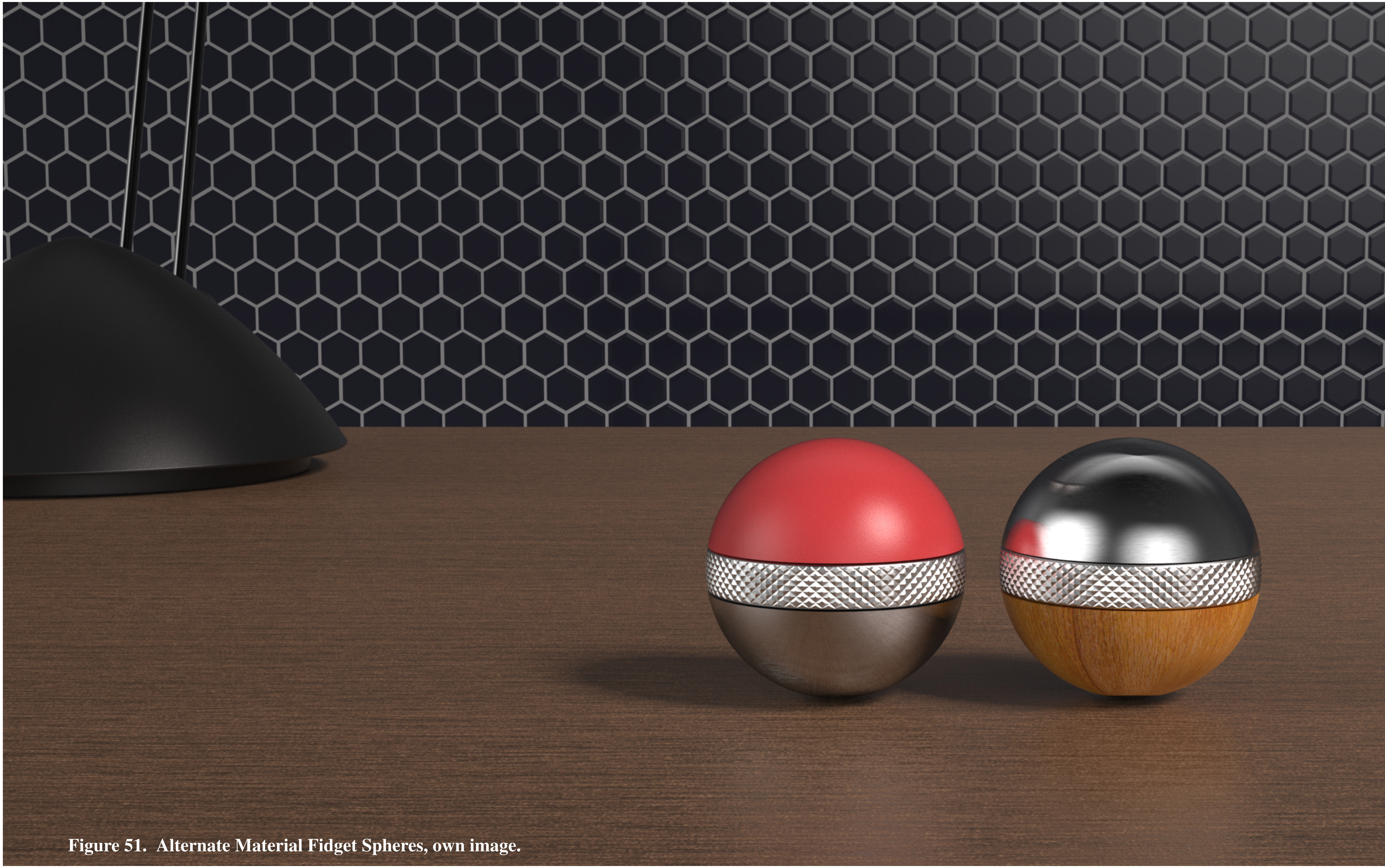


Figure 51. Alternate Material Fidget Spheres, own image.

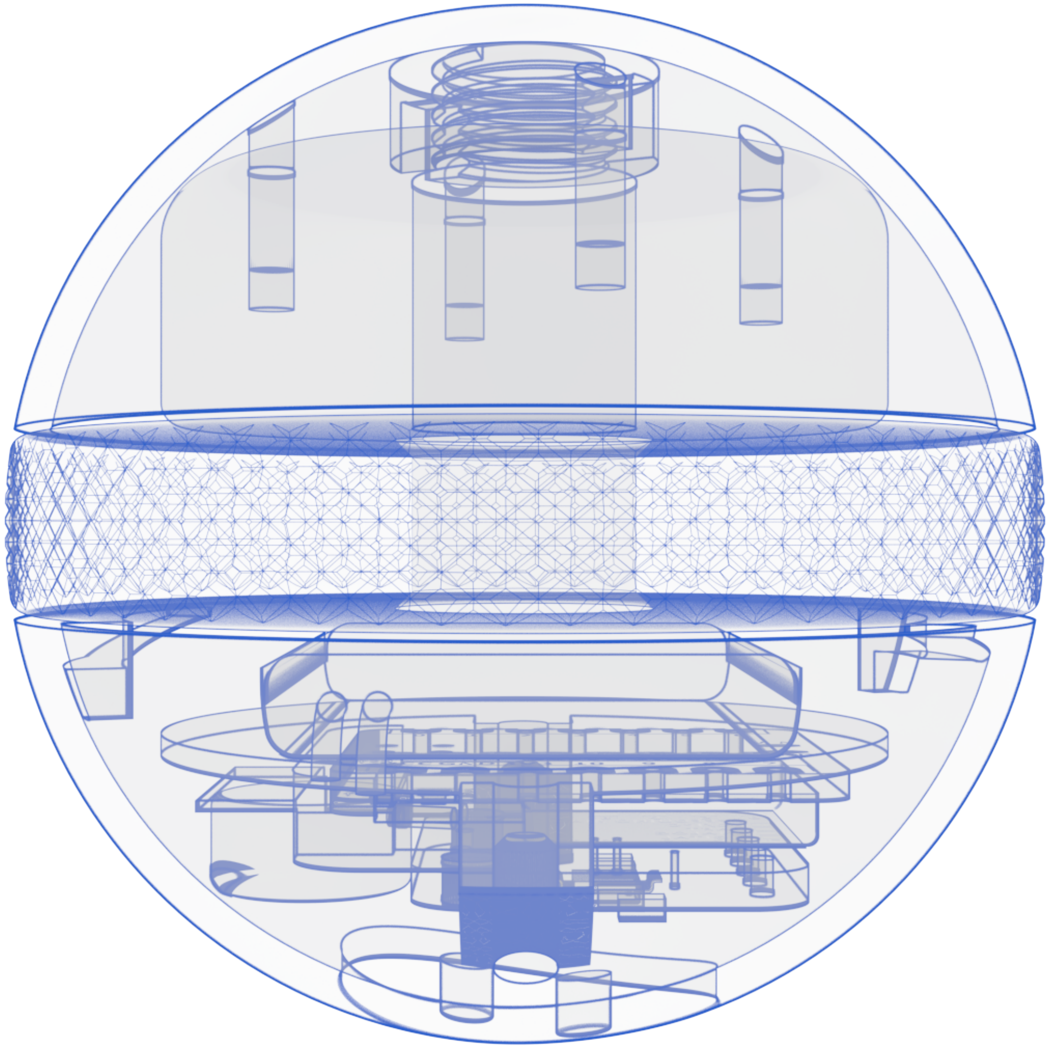


Figure 52. Fidget Spheres Xray View, own image

Figure 53. Fidget Spheres In Hand, own image

6.2. Looks Like Prototype

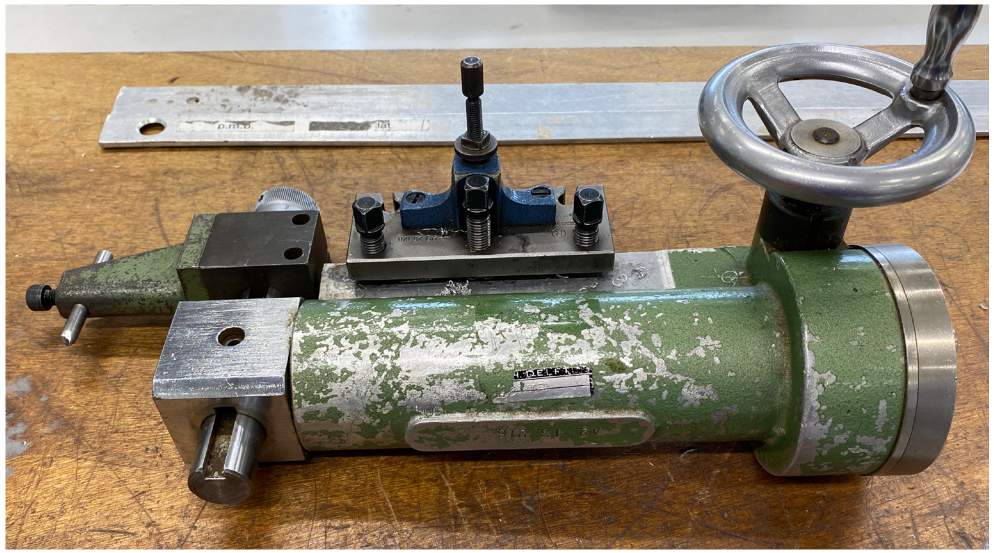
After testing the prototype and creating a digital representation of the final envisioned concept, we sought to produce a physical representation of the product. A "looks like" prototype was constructed to make it more tangible for both the author and an audience. This was also a time intensive process, requiring detailed hand fabrication on a turning lathe (Figure 54) in the PMB machine shop at the IDE faculty. This prototype is purely for aesthetics, though care was taken to enable a spinning ring through tight tolerancing of parts. The following figures show the prototype itself and key moments of the construction process.

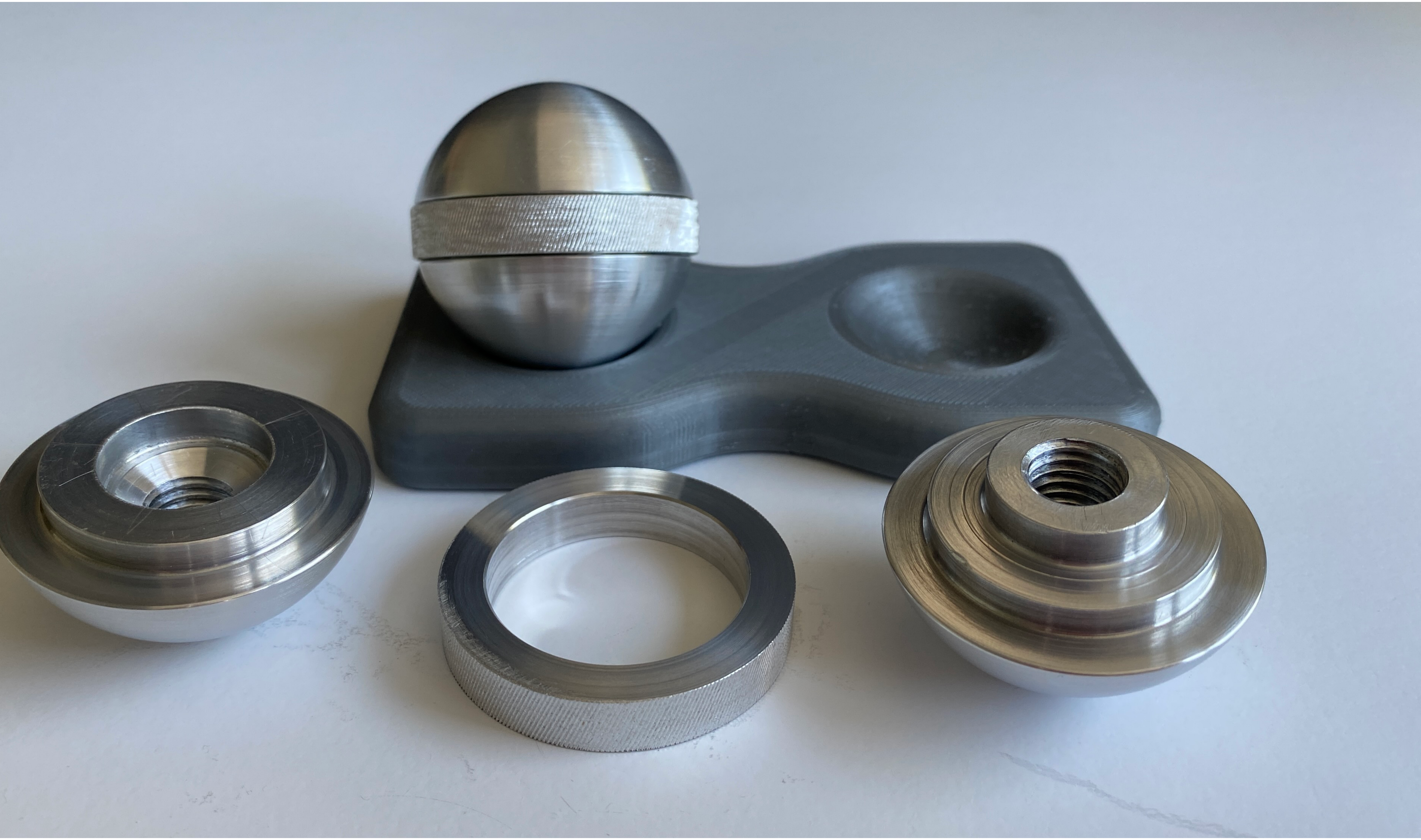
Figure 54. Hemisphere Body Being Screwed On Custom Lathe Fixture

Figure 55. (Next Spread) Fidget Spheres Looks Like Prototype with Stand

Figure 56. Sphere Rounding Process

Figure 57. Adjustable Radius Cutting Tool





Conclusions

The final envisioned Fidget Spheres concept does not mark a radical departure from the tested prototypes in aims or interaction modes. It is obviously much more polished and complete but maintains the core principles. A future graduation project could construct the device as represented here, or with small modification, and test specific implementations of feedback strength and patterns to determine what has the greatest effect.

We now turn towards the original research aims and questions of the project and evaluate whether they have been answered through the literature research, applied activities, the tested prototype and the envisioned final concept.

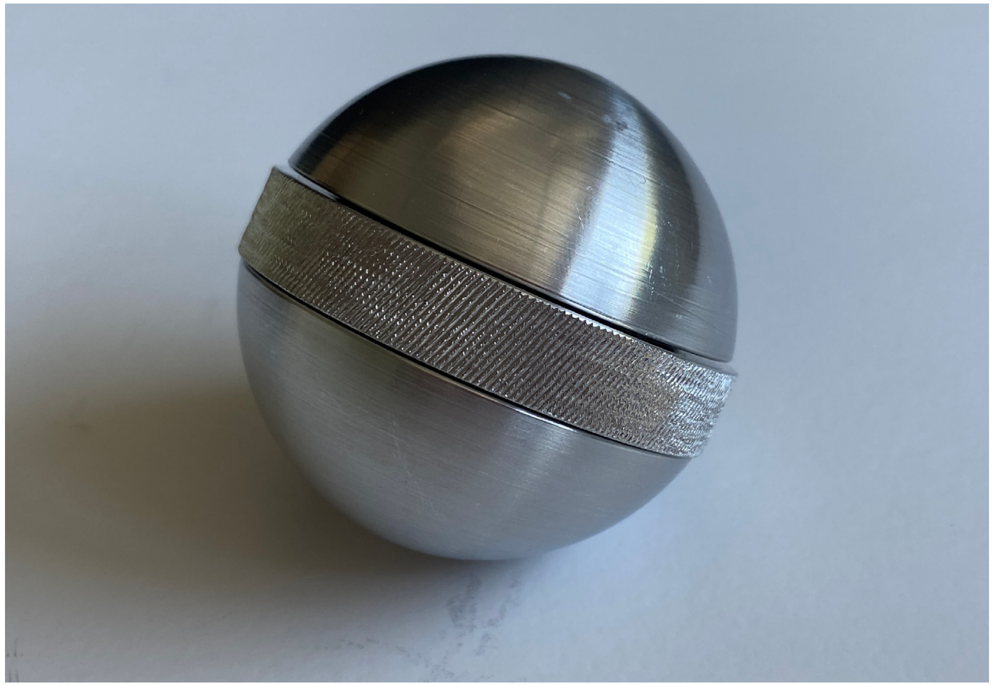


Figure 58. One of Two Fidget Spheres

6

7. Conclusion and Future Developments

7.1. General Future Directions

This chapter marks the end of the graduation journey, as all projects have a duration of 100 working days. Given this constraint, opportunities still exist to further develop the project and envisioned product, to test and (dis)prove Reflexive Focus Bounding, and to validate the design choices made in prototyping. This chapter serves to structure those potential future developments, as well as to tie together the work done and reiterate the value of what has been learned.

Through this project, we have constructed an understanding of fidgeting as a behavior, as well as designed artefacts to leverage this knowledge in pursuit of affect regulation, specifically towards a “productive” state. The theoretical research, both from literature and applied to data sets, has yielded a holistic understanding of fidgeting in a design context. We expect this knowledge could be used as a substantial basis for future projects in this space that narrow down further on the embodiment of a fidget object. Many of the conclusions drawn match well with the work of Karlesky and Isbister (from whom the Fidget Widget data set was borrowed). This is potentially a result of the common data set, but also serves as a form of cross-checking validation. Future work can look to critique these conclusions through counterexamples and analysis of alterative data sets.

This project also contrasts in-vogue “mindfulness” with the “mindless” fidgeting behaviors that are pervasive in daily life. We propose mindless fidgeting as a tool for affect regulation through awareness of internal state, a similar proposition to that of mindfulness meditation. Despite their almost diametrically opposed definitions, mindlessness and mindfulness are interlinked and related through the results of this project. Future work can further clarify what it means to “mindlessly” interact with a product and create criteria by which one could design for this attribute as this project only leverages an existing mindless behavior. Within this topic, the Reflexive Focus Bounding theory also deserves further study.

Alongside the general conclusions and proposals for future work in the same academic space, there are some clear and actionable steps one could take to further develop this project in specific and enable better testing and validation of the Fidget Spheres concept. While not yet designed, we envision a future Fidget Spheres that are proactive in aiding affect regulation. As mentioned in the final concept section, they could link with our computer and other elements of the environment to generate a more holistic understanding of our activities in and movement through the world. This would better inform affect awareness interventions.

If informed by our manner of using a computer (for work or distraction), one could utilize algorithms like popular social media that can determine user engagement through scrolling and swiping behaviors. This can be used to recognize when one's computer use is expressive of mind wandering and intervene through providing haptic feedback in the Fidget Spheres.

These are just a few of the potential future developments one could conduct using this project as a basic foundation. Next, we highlight some very immediate and actionable next steps to develop the Fidget Spheres further.

7.2. Actionable Future Steps

We view the highest priority agenda item is to test assumption that fidgeting behavior can reveal something about one's affective state, specifically the arousal dimension. We believe this to be true from literature research and first-person accounts of fidgeting, however, a targeted, official experiment is merited.

7

Next is to exploration of different feedback modalities other than vibration and force feedback. A significant amount of research was conducted into temperature as feedback in the early stages of this project, which revealed significant knowledge gaps and opportunity to use heat as an "implicit" feedback mode. If vibration feedback is still maintained, an isolated study could test which specific patterns of vibrotactile feedback are perceived as most interruptive, or whether certain patterns communicate specific latent emotional meaning. These results could better inform the choice of vibration feedback within our products.

After these two developments, a more general extended user test with an improved prototype would be valuable. This is possible once some amount of the envisioned final concept is translated into an embodied, real prototype. The following developments are necessary and ordered by importance:

- Step 1: Integrate the battery into the sphere shell
- Step 2: Add the microcontroller/processor in the shell
- Step 3: Execute code changes to move vibration feedback to different timeframe and patterns based on focus group evaluation feedback
- Step 4: Run a new user test on the 2 Fidget Spheres research artefacts
- Step 5: Test unified one-ball for squeeze and for rotation (2 sensors in one shell, feedback in a second ball).
- Step 6: Bring together feedback and dual sensors in a ball (2 times for complete set
- Step 7: Run another user test with the integrated standalone Fidget Spheres.

Next (or parallel) to this, one can develop the Haptic Knob for integration in the project. At this point, one will likely need custom printed circuit boards and electronics to fit the proper packaging of the Fidget Sphere, which adds considerable development time and effort. First, however, the force feedback spinning ring should be prototyped at larger scale in the following order.

- Step 1: reproduce at a larger scale
- Step 2: Miniaturize for sphere
- Step 3: Include with other electronics

These are in no way an exhaustive list of future improvements to be made, but simply represent the most pressing and immediately relevant opportunities. To conclude and summarize the project outcomes, we return to the research questions posed at the start and respond to each in turn.

7.3. Evaluation of Research Questions

Each research question sought to guide our research and explorations during this graduation project. We respond to each to wrap up our findings.

1.1 – What (tactile) sensory interactions can contribute to effective affect self-regulation, specifically of negatively valenced states?

It is difficult to tie any specific physical movement or sensation to the ability to self-regulate affect, though some small things are known, such as cold materials feeling calmer. Every person has a distinct preference for tactile interaction, and thus universal conclusions here are unfounded. We discovered that effective self-regulation first requires awareness of affect, so we focus on a product that can bring attention to one's internal state. Negatively valenced affect can sometimes be distinguished from positive valence through use of biosensing, but this fell outside the project scope.

1.2 – Can tactile fidgeting behavior precipitate an awareness of one's lived, bodily experience?

When structured as an unaware interaction, we can leverage haptic feedback as a mildly interruptive sensory input to help draw awareness towards one's internal, affective state. This is especially true if the interaction involves dynamic and personal feedback that is not intentionally generated through interaction (implicit).

2 – How does implicit "mindless" physical activity promote wellness (as compared to explicit "mindful" activity)?

Despite mindfulness and mindlessness having opposite and exclusive definitions, much of the beneficial effect of fidgeting aligns with the aims of mindfulness meditation. Mindful activities focus on a conscious knowledge and acceptance of one's thoughts and state of being. Mindless activities normally do not touch these subjects, however, the Fidget Spheres constructed interaction (transitioning from unaware to aware) can bring similar awareness to one's internal state, albeit in a more momentary fashion. Even in defining Reflexive Focus Bounding, we use a phrase "attentional anchor" that is borrowed from mindfulness practices. We conclude that both mindful and mindless activities can promote wellness, and mindless fidgeting has a unique opportunity space being an in-the-moment intervention suitable while focusing on a primary task.

3 – How can we conceptualize and understand the benefits of fidgeting behavior?

Prevailing academic literature has not reached a consensus on the benefits of fidgeting, though much of it skews pessimistic. However, fidgeting is seen by those who fidget to be useful in aiding focus, anxiety, creative ideation, and more.

We use the thematic map stemming from Reflexive Thematic Analysis to create a conceptual understanding of fidgeting as a behavior, revealing 6 key aspects. We see fidgeting as primarily benefitting attention and cultivating a 'productive' mood, and our prototype enables people to leverage their fidgeting behaviors in pursuit of a more positive and productive affect.

As one can see, the guiding questions were satisfactorily answered by the results developed during this project. While much work remains to fully validate and refine the findings, this only speaks to the yet-untapped potential of this area of study. With this, we conclude the master's thesis on leverage fidgeting for regulation of a 'productive' mood state. The author can be found at https://www.linkedin.com/in/jackaeichenlaub/ for questions or comments on this work.

Fin

8. References

Alfaras, M., Tsaknaki, V., Sanches, P., Windlin, C., Umair, M., Sas, C., & Höök, K. (2020). From Biodata to Somadata. Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems, 1–14. https://doi.org/10.1145/3313831.3376684

Alonso, M. B., Keyson, D. V., & Hummels, C. C. M. (2008). Squeeze, rock, and roll; can tangible interaction with affective products support stress reduction? Proceedings of the 2nd International Conference on Tangible and Embedded Interaction - TEI '08, 105. https://doi.org/10.1145/1347390.1347413

Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. Journal of Experimental Psychology: General, 130(2), 224–237. https://doi.org/10.1037/0096-3445.130.2.224

Baird, B., Smallwood, J., Mrazek, M. D., Kam, J. W. Y., Franklin, M. S., & Schooler, J. W. (2012). Inspired by Distraction: Mind Wandering Facilitates Creative Incubation. Psychological Science, 23(10), 1117–1122. https://doi.org/10.1177/0956797612446024

Boehner, K., DePaula, R., Dourish, P., & Sengers, P. (2007). How emotion is made and measured. International Journal of Human-Computer Studies, 65(4), 275–291. https://doi.org/10.1016/j.ijhcs.2006.11.016

Bradley, M. M., Greenwald, M. K., Petry, M. C., & Lang, P. J. (1992). Remembering pictures: Pleasure and arousal in memory. Journal of Experimental Psychology: Learning, Memory, and Cognition, 18(2), 379–390. https://doi.org/10.1037/0278-7393.18.2.379

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Braun, V., & Clarke, V. (2012). Thematic analysis. In H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf, & K. J. Sher (Eds.), APA handbook of research methods in psychology, Vol 2: Research designs: Quantitative, qualitative, neuropsychological, and biological. (pp. 57–71). American Psychological Association. https://doi.org/10.1037/13620-004

Bruineberg, J., & Fabry, R. E. (2021). Habitual smartphone use as extended mind-wandering. 33.

Bruns Alonso, M. (2010). Relax!: Inherent feedback during product interaction to reduce stress. s.n.

Bruns Alonso, M., Hummels, C. C. M., Keyson, D. V., & Hekkert, P. P. M. (2013). Measuring and adapting behavior during product interaction to influence affect. Personal and Ubiquitous Computing, 17(1), 81–91. https://doi.org/10.1007/s00779-011-0472-3

Byrne, D. (2021). A worked example of Braun and Clarke's approach to reflexive thematic analysis. Quality & Quantity. https://doi.org/10.1007/s11135-021-01182-y

Chang, H. (2016). Autoethnography in Health Research: Growing Pains? Qualitative Health Research, 26(4), 443–451. https://doi.org/10.1177/1049732315627432

Clarke, V., & Braun, V. (2014). Thematic Analysis. In T. Teo (Ed.), Encyclopedia of Critical Psychology (pp. 1947–1952). Springer New York. https://doi.org/10.1007/978-1-4614-5583-7_311

Cohen, E. J., Bravi, R., & Minciacchi, D. (2018). The effect of fidget spinners on fine motor control. Scientific Reports, 8(1), 3144. https://doi.org/10.1038/s41598-018-21529-0

Costa, J., Adams, A. T., Jung, M. F., Guimbretière, F., & Choudhury, T. (2016). EmotionCheck: Leveraging bodily signals and false feedback to regulate our emotions. Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing, 758–769. https://doi.org/10.1145/2971648.2971752

Csikszentmihalyi, M., & Larson, R. (2014). Validity and Reliability of the Experience-Sampling Method. In M. Csikszentmihalyi, Flow and the Foundations of Positive Psychology (pp. 35–54). Springer Netherlands. https://doi.org/10.1007/978-94-017-9088-8_3

da Câmara, S. B., Agrawal, R., & Isbister, K. (2018). Identifying Children's Fidget Object Preferences: Toward Exploring the Impacts of Fidgeting and Fidget-Friendly Tangibles. Proceedings of the 2018 Designing Interactive Systems Conference, 301–311. https://doi.org/10.1145/3196709.3196790

Desmet, P. (2003). Measuring Emotion: Development and Application of an Instrument to Measure Emotional Responses to Products. In M. A. Blythe, K. Overbeeke, A. F. Monk, & P. C. Wright (Eds.), Funology (Vol. 3, pp. 111–123). Springer Netherlands. https://doi.org/10.1007/1-4020-2967-5_12

Desmet, P. M. A. (2012). Faces of Product Pleasure: 25 Positive Emotions in Human-Product Interactions. 30.

Desmet, P. M. A., Fokkinga, S. F., & Xue, H. (2020). Twenty moods: Holistic typology of human mood states. Delft University of Technology.

Desmet, P. M. A., & Pohlmeyer, A. E. (2013). An Introduction to Design for Subjective Well-Being. 7(3), 16.

Desmet, P., Overbeeke, K., & Tax, S. (2001). Designing Products with Added Emotional Value: Development and Appllcation of an Approach for Research through Design. The Design Journal, 4(1), 32–47. https://doi.org/10.2752/146069201789378496

Djajadiningrat, T., Geurts, L., Christiaansen, G., & Kyffin, S. (2008). Mindspheres Play your skills, relax your mind. 5.

Dourish, P. (1999). Embodied Interaction: Exploring the Foundations of a New Approach to HCI. ToCHI, 17.

Dourish, P. (2001). Where the Action Is: The Foundations of Embodied Interaction. The MIT Press. https://doi.org/10.7551/mitpress/7221.001.0001

Duijzer, C. A. C. G., Shayan, S., Bakker, A., Van der Schaaf, M. F., & Abrahamson, D. (2017). Touchscreen Tablets: Coordinating Action and Perception for Mathematical Cognition. Frontiers in Psychology, 8. https://doi.org/10.3389/fpsyg.2017.00144

Ekman, P. (1992). An argument for basic emotions. Cognition and Emotion, 6(3–4), 169–200. https://doi.org/10.1080/02699939208411068

Farley, J., Risko, E. F., & Kingstone, A. (2013). Everyday attention and lecture retention: The effects of time, fidgeting, and mind wandering. Frontiers in Psychology, 4. https://doi.org/10.3389/fpsyg.2013.00619

Fokkinga, S. F. (2015). Design -|+: Negative emotions for positive experiences [Delft University of Technology]. https://doi.org/10.4233/UUID:F81FBAAB-B3D1-407D-98D4-6775FED-2EC81

Giaccardi, E., & Karana, E. (2015). Foundations of Materials Experience: An Approach for HCI. Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems, 2447–2456. https://doi.org/10.1145/2702123.2702337

Gibson, J. J. (1962). Observations on active touch. Psychological Review, 69(6), 477–491. https://doi.org/10.1037/h0046962

Gould, S. J. (1995). Researcher Introspection as a Method in Consumer Research: Applications, Issues, and Implications. Journal of Consumer Research, 21(4), 719. https://doi.org/10.1086/209430

Goyal, M., Singh, S., Sibinga, E. M. S., Gould, N. F., Rowland-Seymour, A., Sharma, R., Berger, Z., Sleicher, D., Maron, D. D., Shihab, H. M., Ranasinghe, P. D., Linn, S., Saha, S., Bass, E. B.,

& Haythornthwaite, J. A. (2014). Meditation Programs for Psychological Stress and Well-being: A Systematic Review and Meta-analysis. JAMA Internal Medicine, 174(3), 357. https://doi.org/10.1001/jamainternmed.2013.13018

Gross, J. J. (1998). The Emerging Field of Emotion Regulation: An Integrative Review. Review of General Psychology, 2(3), 271–299. https://doi.org/10.1037/1089-2680.2.3.271

Gross, J. J. (2002). Emotion regulation: Affective, cognitive, and social consequences. Psychophysiology, 39(3), 281–291. https://doi.org/10.1017/S0048577201393198

Gross, J. J. (2015). The Extended Process Model of Emotion Regulation: Elaborations, Applications, and Future Directions. Psychological Inquiry, 26(1), 130–137. https://doi.org/10.1080/1047840X.2015.989751

Guribye, F., Gjøsæter, T., & Bjartli, C. (2016). Designing for Tangible Affective Interaction. Proceedings of the 9th Nordic Conference on Human-Computer Interaction, 1–10. https://doi.org/10.1145/2971485.2971547

Hall, P. M. (2007). Symbolic Interaction. In G. Ritzer (Ed.), The Blackwell Encyclopedia of Sociology (p. wbeoss310). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781405165518.wbeoss310

Hiniker, A., Patel, S. N., Kohno, T., & Kientz, J. A. (2016). Why would you do that? Predicting the uses and gratifications behind smartphone-usage behaviors. Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing, 634–645. https://doi.org/10.1145/2971648.2971762

Hölzel, B. K., Lazar, S. W., Gard, T., Schuman-Olivier, Z., Vago, D. R., & Ott, U. (2011). How Does Mindfulness Meditation Work? Proposing Mechanisms of Action From a Conceptual and Neural Perspective. Perspectives on Psychological Science, 6(6), 537–559. https://doi.org/10.1177/1745691611419671

Höök, K. (2008). Affective Loop Experiences – What Are They? In H. Oinas-Kukkonen, P. Hasle, M. Harjumaa, K. Segerståhl, & P. Øhrstrøm (Eds.), Persuasive Technology (Vol. 5033, pp. 1–12). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-68504-3_1

Höök, K., Jonsson, M. P., Ståhl, A., & Mercurio, J. (2016). Somaesthetic Appreciation Design. Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems, 3131–3142. https://doi.org/10.1145/2858036.2858583

Höök, K., Ståhl, A., Jonsson, M., Mercurio, J., Karlsson, A., & Johnson, E.-C. B. (2015). Somaesthetic design. Interactions, 22(4), 26–33. https://doi.org/10.1145/2770888

Hussien Ahmed, M. M., Silpasuwanchai, C., Salehzadeh Niksirat, K., & Ren, X. (2017). Understanding the Role of Human Senses in Interactive Meditation. Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems, 4960–4965. https://doi.org/10.1145/3025453.3026000

Isbister, K., & Karlesky, Michael. (2016). Understanding Fidget Widgets: Exploring the Design Space of Embodied Self-Regulation. Proceedings of the 9th Nordic Conference on Human-Computer Interaction, 1–10. https://doi.org/10.1145/2971485.2971557

James, W. (1890). The principles of psychology, Vol I. Henry Holt and Co. https://doi.org/10.1037/10538-000

James, W. (1905). The experience of activity. Psychological Review, 12(1), 1–17. https://doi.org/10.1037/h0070340

Jonsson, M., Ståhl, A., Mercurio, J., Karlsson, A., Ramani, N., & Höök, K. (2016). The Aesthetics of Heat: Guiding Awareness with Thermal Stimuli. Proceedings of the TEI '16: Tenth International Conference on Tangible, Embedded, and Embodied Interaction, 109–117. https://doi.org/10.1145/2839462.2839487

Kanjo, E., Al-Husain, L., & Chamberlain, A. (2015). Emotions in context: Examining pervasive affective sensing systems, applications, and analyses. Personal and Ubiquitous Computing, 19(7), 1197–1212. https://doi.org/10.1007/s00779-015-0842-3

Karlesky, M., & Isbister, K. (2013). Designing for the physical margins of digital workspaces: Fidget widgets in support of productivity and creativity. Proceedings of the 8th International Conference on Tangible, Embedded and Embodied Interaction - TEI '14, 181–188. https://doi.org/10.1145/2540930.2540934

Korn, O., Stamm, L., & Moeckl, G. (2017). Designing Authentic Emotions for Non-Human Characters: A Study Evaluating Virtual Affective Behavior. Proceedings of the 2017 Conference on Designing Interactive Systems, 477–487. https://doi.org/10.1145/3064663.3064755

Krisanaprakornkit, T., Sriraj, W., Piyavhatkul, N., & Laopaiboon, M. (2006). Meditation therapy for anxiety disorders. Cochrane Database of Systematic Reviews. https://doi.org/10.1002/14651858.CD004998.pub2

Krøger, E., Guribye, F., & Gjøs, T. (2015). LOGGING AND VISUALIZING AFFECTIVE INTERACTION FOR MENTAL HEALTH THERAPY. 15.

Liang, R.-H., Yu, B., Xue, M., Hu, J., & Feijs, L. M. G. (2018). BioFidget: Biofeedback for Respiration Training Using an Augmented Fidget Spinner. Proceedings of the 2018 CHI Conference on

Human Factors in Computing Systems, 1–12. https://doi.org/10.1145/3173574.3174187

Lin, C.-T., Chuang, C.-H., Kerick, S., Mullen, T., Jung, T.-P., Ko, L.-W., Chen, S.-A., King, J.-T., & McDowell, K. (2016). Mind-Wandering Tends to Occur under Low Perceptual Demands during Driving. Scientific Reports, 6(1), 21353. https://doi.org/10.1038/srep21353

Mrazek, M. D., Smallwood, J., & Schooler, J. W. (2012). Mindfulness and mind-wandering: Finding convergence through opposing constructs. Emotion, 12(3), 442–448. https://doi.org/10.1037/a0026678

Norman, D. A. (2013). The design of everyday things (Rev. and expanded ed). MIT Press.

Pal, S., Mukhopadhyay, S., & Suryadevara, N. (2021). Development and Progress in Sensors and Technologies for Human Emotion Recognition. Sensors. https://doi.org/10.3390/s21165554

Russell, J. A. (1980). A circumplex model of affect. Journal of Personality and Social Psychology, 39(6), 1161–1178. https://doi.org/10.1037/h0077714

Salminen, K., Surakka, V., Raisamo, J., Lylykangas, J., Raisamo, R., Mäkelä, K., & Ahmaniemi, T. (2013). Cold or Hot? How Thermal Stimuli Are Related to Human Emotional System? In I. Oakley & S. Brewster (Eds.), Haptic and Audio Interaction Design (Vol. 7989, pp. 20–29). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-41068-0_3

Schecter, R. A., Shah, J., Fruitman, K., & Milanaik, R. L. (2017). Fidget spinners: Purported benefits, adverse effects and accepted alternatives. Current Opinion in Pediatrics, 29(5), 616–618. https://doi.org/10.1097/MOP.0000000000000523

Schiphorst, T. (2009). soft(n): Toward a somaesthetics of touch. CHI '09 Extended Abstracts on Human Factors in Computing Systems, 2427–2438. https://doi.org/10.1145/1520340.1520345

Schmidt, A. (2000). Implicit human computer interaction through context. Personal Technologies, 4(2–3), 191–199. https://doi.org/10.1007/BF01324126

Sedlmeier, P., Eberth, J., Schwarz, M., Zimmermann, D., Haarig, F., Jaeger, S., & Kunze, S. (2012). The psychological effects of meditation: A meta-analysis. Psychological Bulletin, 138(6), 1139–1171. https://doi.org/10.1037/a0028168

Seli, P. (2019). What's in a task? Complications in the study of the task-unrelated-thought (TUT) variety of mind wandering [Preprint]. PsyArXiv. https://doi.org/10.31234/osf.io/fsg57

Seli, P., Beaty, R. E., Cheyne, J. A., Smilek, D., Oakman, J., & Schacter, D. L. (2018). How pervasive is mind wandering, really?,. Consciousness and Cognition, 66, 74–78. https://doi.

org/10.1016/j.concog.2018.10.002

Seli, P., Carriere, J. S. A., Thomson, D. R., Cheyne, J. A., Martens, K. A. E., & Smilek, D. (2014). Restless mind, restless body. Journal of Experimental Psychology: Learning, Memory, and Cognition, 40(3), 660–668. https://doi.org/10.1037/a0035260

Seli, P., Smallwood, J., Cheyne, J. A., & Smilek, D. (2015). On the relation of mind wandering and ADHD symptomatology. Psychonomic Bulletin & Review, 22(3), 629–636. https://doi.org/10.3758/s13423-014-0793-0

Serim, B., & Jacucci, G. (2019). Explicating "Implicit Interaction": An Examination of the Concept and Challenges for Research. Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, 1–16. https://doi.org/10.1145/3290605.3300647

Shapiro, L., & Spaulding, S. (2021). Embodied Cognition. In E. N. Zalta (Ed.), The Stanford Encyclopedia of Philosophy (Winter 2021). Metaphysics Research Lab, Stanford University. https://plato-stanford-edu.tudelft.idm.oclc.org/archives/win2021/entries/embodied-cognition/

Shusterman, R. (1999). Somaesthetics: A Disciplinary Proposal. The Journal of Aesthetics and Art Criticism, 15.

Shusterman, R. (2020). Somaesthetics in Context. Kinesiology Review, 9(3), 245–253. https://doi.org/10.1123/kr.2020-0019

Siegle, G. J., & Rabin, D. M. L. (2019). Regulatory device and associated method (US Patent & Trademark Office Patent). https://patents.google.com/patent/US20190076643A1/en?

Smallwood, J., Fitzgerald, A., Miles, L. K., & Phillips, L. H. (2009). Shifting moods, wandering minds: Negative moods lead the mind to wander. Emotion, 9(2), 271–276. https://doi.org/10.1037/a0014855

Smallwood, J., Obonsawin, M., & Heim, D. (2003). Task unrelated thought: The role of distributed processing. Consciousness and Cognition, 12(2), 169–189. https://doi.org/10.1016/S1053-8100(02)00003-X

Soares, J. S., & Storm, B. C. (2020). Putting a negative spin on it: Using a fidget spinner can impair memory for a video lecture. Applied Cognitive Psychology, 34(1), 277–284. https://doi.org/10.1002/acp.3610

Spreng, R. N. (2012). The Fallacy of a "Task-Negative" Network. Frontiers in Psychology, 3. https://doi.org/10.3389/fpsyg.2012.00145

Ståhl, A., Jonsson, M., Mercurio, J., Karlsson, A., Höök, K., & Banka Johnson, E.-C. (2016).

The Soma Mat and Breathing Light. Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems, 305–308. https://doi.org/10.1145/2851581.2889464

Stawarczyk, D., Majerus, S., & D'Argembeau, A. (2013). Concern-induced negative affect is associated with the occurrence and content of mind-wandering. Consciousness and Cognition, 22(2), 442–448. https://doi.org/10.1016/j.concog.2013.01.012

Tsaknaki, V. (2021). The Breathing Wings: An Autobiographical Soma Design Exploration of Touch Qualities through Shape-Change Materials. Designing Interactive Systems Conference 2021, 1266–1279. https://doi.org/10.1145/3461778.3462054

Tsaknaki, V., Cotton, K., Karpashevich, P., & Sanches, P. (2021). "Feeling the Sensor Feeling you": A Soma Design Exploration on Sensing Non-habitual Breathing. Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, 1–16. https://doi.org/10.1145/3411764.3445628

Umair, M., Chalabianloo, N., Sas, C., & Ersoy, C. (2021). HRV and Stress: A Mixed-Methods Approach for Comparison of Wearable Heart Rate Sensors for Biofeedback. IEEE Access, 9, 14005–14024. https://doi.org/10.1109/ACCESS.2021.3052131

Umair, M., Sas, C., Chalabianloo, N., & Ersoy, C. (2021). Exploring Personalized Vibrotactile and Thermal Patterns for Affect Regulation. Designing Interactive Systems Conference 2021, 891–906. https://doi.org/10.1145/3461778.3462042

Wensveen, S. A. G., Djajadiningrat, J. P., & Overbeeke, C. J. (2004). Interaction frogger: A design framework to couple action and function through feedback and feedforward. Proceedings of the 2004 Conference on Designing Interactive Systems Processes, Practices, Methods, and Techniques - DIS '04, 177. https://doi.org/10.1145/1013115.1013140

Wilson, G., Dobrev, D., & Brewster, S. A. (2016). Hot Under the Collar: Mapping Thermal Feedback to Dimensional Models of Emotion. Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems, 4838–4849. https://doi.org/10.1145/2858036.2858205

Xue, H., & Desmet, P. M. A. (2019). Researcher introspection for experience-driven design research. Design Studies, 63, 37–64. https://doi.org/10.1016/j.destud.2019.03.001

Xue, H., Desmet, P. M. A., & Fokkinga, S. F. (2020). Mood Granularity for Design: 14(1), 18.

Zimmerman, J., Forlizzi, J., & Evenson, S. (2007). Research through design as a method for interaction design research in HCI. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 493–502. https://doi.org/10.1145/1240624.1240704

9. Figures (Sources and Licences)

Figure 4 - Rob Tieben, 2015. Activating Play: a design research study on how to elicit playful interaction from teenagers. DOI: 10.13140/RG.2.1.2470.4488.

Figure 6 - Cohen, E. J., Bravi, R., & Minciacchi, D. (2018). The effect of fidget spinners on fine motor control. Scientific Reports, 8(1), 3144. https://doi.org/10.1038/s41598-018-21529-0

Figure 7 - Emotion typology : https://emotiontypology.com/, CC BY-NC-ND 4.0

Figure 8 - Korn, O., Stamm, L., & Moeckl, G. (2017). Designing Authentic Emotions for Non-Human Characters: A Study Evaluating Virtual Affective Behavior. Proceedings of the 2017 Conference on Designing Interactive Systems, 477–487. https://doi.org/10.1145/3064663.3064755

Figure 10 - Desmet, P. M. A., Fokkinga, S. F., & Xue, H. (2020). Twenty moods: Holistic typology of human mood states. Delft University of Technology.

Figure 11 - Kstan. Own work, based on Gross, J.J. (2013). Emotion Regulation: Taking stock and moving forward. Emotion, 13(3), 359-365. doi: 10.1037/a0032135. CC BY-SA 3.0

Figure 12 - Desmet, P. M. A., & Pohlmeyer, A. E. (2013). An Introduction to Design for Subjective Well-Being. 7(3), 16.

Figure 13 - Huisman, G., Darriba Frederiks, A., Van Dijk, B., Hevlen, D., & Krose, B. (2013). The TaSSt: Tactile sleeve for social touch. 2013 World Haptics Conference (WHC), 211–216. https://doi.org/10.1109/WHC.2013.6548410

Figure 14, 15 - Bruns Alonso, M., Hummels, C. C. M., Keyson, D. V., & Hekkert, P. P. M. (2013). Measuring and adapting behavior during product interaction to influence affect. Personal and Ubiquitous Computing, 17(1), 81–91. https://doi.org/10.1007/s00779-011-0472-3

Figure 16 - Own work. Adapted from Serim, B., & Jacucci, G. (2019). Explicating "Implicit Interaction": An Examination of the Concept and Challenges for Research. Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, 1–16. https://doi.org/10.1145/3290605.3300647

Figure 17 - RaDIo for New York Times, https://www.nytimes.com/2021/08/24/magazine/how-to-let-your-mind-wander.html

Figure 18 - https://shine365.marshfieldclinic.org/wp-content/uploads/2016/08/Fidgeting-Hand-F-76807186.jpg

Figure 19 - Own work. Adapted from Bruineberg, J., & Fabry, R. E. (2021). Habitual smartphone use as extended mind-wandering. 33.

Figure 21 - 3 sources: https://commons.wikimedia.org/wiki/File:Max_Health_Band.jpg; https://commons.wikimedia.org/wiki/File:Final_5dff67f59d8d9300145440a4_3.gif; https://commons.wikimedia.org/wiki/File:Electromyographic_recording_at_adductor_pollicis_muscle_and_stimulation_of_the_ulnar_nerve.jpg. CC BY-SA 4.0.

Figure 22 - Tsaknaki, V. (2021). The Breathing Wings: An Autobiographical Soma Design Exploration of Touch Qualities through Shape-Change Materials. Designing Interactive Systems Conference 2021, 1266–1279. https://doi.org/10.1145/3461778.3462054 Tsaknaki, V., Cotton, K., Karpashevich, P., & Sanches, P. (2021). "Feeling the Sensor Feeling you": A Soma Design Exploration on Sensing Non-habitual Breathing. Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, 1–16. https://doi.org/10.1145/3411764.3445628

Figure 23 - Valerie Lemay. https://ideas.ted.com/the-right-way-to-be-introspective-yes-theres-a-wrong-way/

Figure 27 - Dr. Özgehan Uştuk (Adapted from Braune and Clarke, 2006, 2012). https://www.maxqda.com/blogpost/thematic-analysis-with-maxqda-step-by-step-guide

Figure 29 - StudioLab. https://studiolab.ide.tudelft.nl/studiolab/about/

Figure 32 - Guribye, F., Gjøsæter, T., & Bjartli, C. (2016). Designing for Tangible Affective Interaction. Proceedings of the 9th Nordic Conference on Human-Computer Interaction, 1–10. https://doi.org/10.1145/2971485.2971547; https://www.grasp.global/

Figure 34 - Manfred Werner: https://commons.wikimedia.org/wiki/File:Baoding_Balls_Qi_Gong_Kugeln01.jpg. CC BY-SA 3.0

Figure 38 - Djajadiningrat, T., Geurts, L., Christiaansen, G., & Kyffin, S. (2008). Mindspheres Play your skills, relax your mind. 5.

Figure 40 - Seeed Studio. https://wiki.seeedstudio.com/XIAO_BLE/

Figure 41 - Precision Micro Drives. https://www.precisionmicrodrives.com/ab-018; Texas Instruments. https://e2e.ti.com/blogs_/b/analogwire/posts/how-does-a-linear-resonant-actuator-work

Figure 42 - Adafruit. https://learn.adafruit.com/adafruit-drv2605-haptic-controller-breakout

Figure 43 - Kiwi.nl. https://www.kiwi-electronics.com/en/round-force-sensitive-resistor-fsr-1652

Figure 47 - Julia de Boer/The Next Web: https://commons.wikimedia.org/wiki/File:Anne_Helmond_paying_attention_-_TNW_Conference_2010_-_Day_1_%284559735383%29.jpg. CC BY-SA 2.0

Figure 48 - ScottBez1. https://github.com/scottbez1/smartknob. CC BY 4.0.

10. Appendices

In the interest of environmental and cost consciousness while printing, only one required appendix (the project brief) is included in this printed copy of the thesis report. The rest of the appendices mentioned in this report are available as a digital standalone file. That file can be found at https://drive.google.com/drive/folders/1Z0w8uRqaGe1rQLKVaxvmhtheF2B7eiPB?usp=sharing or on the TU Delft repository. Thanks for your understanding.

List of Appendices:

- Appendix A - Project Brief (Included in main report)
- Appendix B - Somaesthetics Research
- Appendix C - Introspective Fidgeting Survey 1
- Appendix D - Introspective Fidgeting Survey 2
- Appendix E - Codes and Extracts from RTA
- Appendix F - Arduino Prototype Software
- Appendix G - Workshop Prototype Evaluation
- Appendix H - Workshop Breaching Exercise

Appendix A - Project Brief

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy". Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name: Eichenlaub

initials: J.A. given name: John

student number: -------

street & no.: ----------------------

zipcode & city: -------------------------------

country: Netherlands

phone: 06 ---------------------

email: j.a.eichenlaub@student.tudelft.nl

Your master programme (only select the options that apply to you):

IDE master(s): ★ IPD / DfI / SPD

2nd non-IDE master:

individual programme: - - (give date of approval)

honours programme: Honours Programme Master

specialisation / annotation: Medisign / Tech. in Sustainable Design / Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair: Dr. Haian Xue — dept. / section: HCD/Design Aesthetics

** mentor: Dr. Gijs Huisman — dept. / section: HCD/HICD

2nd mentor:

organisation:

city: country:

comments (optional)

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

Sensory Appreciation to Enable Conscious Emotional Self-Regulation — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 15 - 02 - 2022 27 - 07 - 2022 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

One of the most dominant trends of 2017 was the "fidget spinner", a 3-lobed plastic toy (see figure 1) that spun on ball bearings. Instantly popular amongst kids and students, the device was purported to help with concentration, among other benefits. It became explosively popular, spawning and popularizing an industry of related products and creations (again, see figure 1). Scientific research reaches conflicting conclusions as to the efficacy of these devices for emotional regulation, attention, and fine motor control. Some studies report attention increases in user with ADHD, while many report no or adverse effects on learning and memory. See Schecter (2017) for a review and Mennilo (2015), Cohen et al. (2018), and Soares and Storm (2020) for more specific efficacy studies. Quickly fidget spinners were banned in classrooms for the nuisance and health hazards they created, yet some related holdouts remain popular.

Obviously, the aim is not to make a repeat of this device for all its failings. But its existence and the enduring trend of "fidget objects" speaks to an underlying need and desire of a large target group: persistent tactile interaction that helps self-regulate behavior (or at least is perceived to help). This trend is further strengthened by the ongoing coronavirus pandemic and the related lifestyle changes unexpectedly forced upon us. People are inarguably more stressed and anxious than before, and frequently find themselves left alone to deal with those emotions. A tool that allows for independent emotional self-regulation is thus much more immediately relevant than in the near past. The main stakeholders in this project are thus the target "users," which is any person that desires assistance in emotional and behavioral self-regulation. This project fits within the research scope of the Delft Institute of Positive Design, specifically the 5-year VICI grant project on "Mood Regulation by Design" that runs through October 2022.

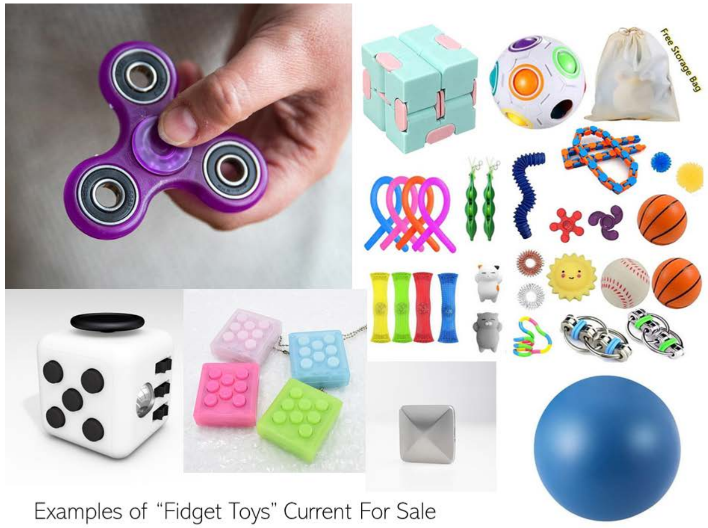
This project will extend from a relatively contemporary philosophy called "somaesthetics," which was developed in the mid-1990s by Richard Shusterman. Somaesthetics rejects mind/body dualism and instead considers one united whole in that experience and emotion are inseparable from our bodily experience. In his 2020 paper "Somaesthetics in Context", Shusterman "outlines the roots of somaesthetics in pragmatist philosophy and the philosophical idea of the holistic art of living." As stated in the same paper, somaesthetic application has the further goal to explore "not merely what the body is but also what it could be through disciplined cultivation." Somaesthetics has already been introduced into the design space, primarily in the HCI field by researchers such as Kristina Höök. She views the primary purpose of somaesthetic design as "making people more aware of their felt bodily experiences" Höök (2015). I consider this aim a necessary precondition to leveraging sensory appreciation to enable conscious emotional self-regulation. Additionally, this increased focus of one's lived experience would help people to be more emotionally present in good and bad experiences, a subgoal of this project.

The technology to support nuanced tactile interaction is highly advanced thanks to smartphones and vibration-feedback interfaces we use regularly. Subject matter research is also very detailed. Expected barriers to project success and adoption are more in behavioral and social norms in the same way that meditation or attending therapy experiences pervasive resistance. The project aims to reduce the time effort required to emotionally self-regulate over existing practices, as that is often a barrier for young people.

As a cultural movement, the younger generations are increasingly focusing on "experiences" over "possessions," and attempting to secure meaningful life experiences in the face of increasing instability. As such, meditation, yoga, and other activities that support being emotionally present are popular. It is time a product was introduced that could achieve similar effects in a robust way and meet this growing cultural need of holistic, present, experiential wellbeing.

space available for images / figures on next page

introduction (continued): space for images



SOURCES

Fidget spinner:
https://www.forbes.com/sites/brucelee/2017/05/19/heres-the-science-behind-the-fidget-spinner-craze/

Composite Toys:
https://www.joom.com/en/products/603b4434e2c02101068c2691

Cube:
https://www.bol.com/nl/nl/p/fidget-cube-wit-zwart/9200000076593566/

Bike Chain:
https://www.geinlaean.cf/products.aspx?cname=bike+chains+fidget+toys&cid=108&xi=3&xc=21

Flippy Square:
https://flippy.dk/vare/quad-flippy/?v=dd65ef9a5579

Bubble Wrap:
https://nl.aliexpress.com/item/32798217312.html

Pea Popper:
https://www.bol.com/nl/nl/p/fidget-bean-fidget-squishy-pop-it-pea-popper-fidget-boontjes-sleutelhanger-fidget-toy-simple-dimple-groen/9300000025202140/

Examples of “Fidget Toys” Current For Sale

image / figure 1: Composite image of the many available fidget devices, each of variable efficacy and purpose

Sources:

Cohen, E.J., Bravi, R. & Minciacchi, D. The effect of fidget spinners on fine motor control. Sci Rep 8, 3144 (2018). https://doi.org/10.1038/s41598-018-21529-0

Höök, K., Ståhl, A., Jonsson, M., Mercurio, J., Karlsson, A., & Johnson, E. C. B. (2015). Somaesthetic design. Interactions, 22(4), 26–33. https://doi.org/10.1145/2770888

Mennillo M. Stop touching things! The role of fidget toys. (23 March 2015). http://occupationaltherapychildren.com.au/stop-touching-things-the-role-offidget-toys/.

Schecter, Rachel A.a; Shah, Jayb; Fruitman, Katec; Milanaik, Ruth Lynnc Fidget spinners: Purported benefits, adverse effects and accepted alternatives, Current Opinion in Pediatrics: October 2017 - Volume 29 - Issue 5 - p 616-618 doi: 10.1097/MOP.0000000000000523

Shusterman, R. (2020). Somaesthetics in context. Kinesiology Review, 9, 245-253. doi:10.1123/kr.2020-0019

Soares, JS, Storm, BC. Putting a negative spin on it: Using a fidget spinner can impair memory for a video lecture. Appl Cognit Psychol. 2020; 34: 277– 284. https://doi.org/10.1002/acp.3610

image / figure 2: Sources

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

The following are structured themes and research questions that define the project scope:
Theme 1: Principles of Emotional Regulation
RQ1.1 - What (tactile) sensory interactions contribute to effective emotion and mood regulation, especially of “undesirable” emotional states?
RQ1.2 - Can tactile interaction contribute to deeper perceptual awareness of one's own body and bodily experience?

Theme 2: "Art of Living" and Somatic Consciousness
RQ2 – In what ways could deeper perceptual awareness (mindfulness) and connoisseurship of the lived mind-body experience benefit people's emotion and mood regulation?

This project seeks to combine traditional research methods with a relatively new field in somaesthetics. Somaesthetics frequently asks for the centering of the lived experience of the designer, contrary to much existing design methodology. This theoretical support for the project is very important to defining the process and scope of my work.

This project ideally produces a solution that enables people outside of the designer themselves to better emotionally self-regulate through an engagement with the full depth and breadth of their experience. Quickly stated: mood regulation by technology-supported somatic mindful practice. In this "experience" is not only emotion and mood, but the physical presence and sensation of one's body in the world. Theme 1 contains the primary research aims for the project. Were those questions to be sufficiently answered, the project could be considered a success. Any further knowledge generated over the second theme would serve to advance somaesthetic design principles as a functional and useful basis for product design.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in “problem definition”. Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

I will deliver a functional prototype of a product/product-service combination that enables conscious emotional self-regulation through the appreciation of sensory experiences, specifically touching/tactile interaction. This design also should encourage living according to “somaesthetic” principles and promote heightened engagement with our everyday experience.

The end deliverable for this project is intentionally vague as it should be driven by the insights of detailed literature review and target group interviews and analysis (a.k.a. the design process). That being said, it's important to me that the project is NOT purely speculative, a museum "installation," or primarily AR/VR based. We are approaching this subject through the lens of somaesthetics and embodied cognition/interaction, and as such it should be grounded in the physical world and readily accessible. "The metaverse" is a hot-button topic and I wish to avoid all the controversy and strong opinion involved with that, thus the aversion to AR/VR implementations. Further, exploring touch is potentially harder in a digital space.

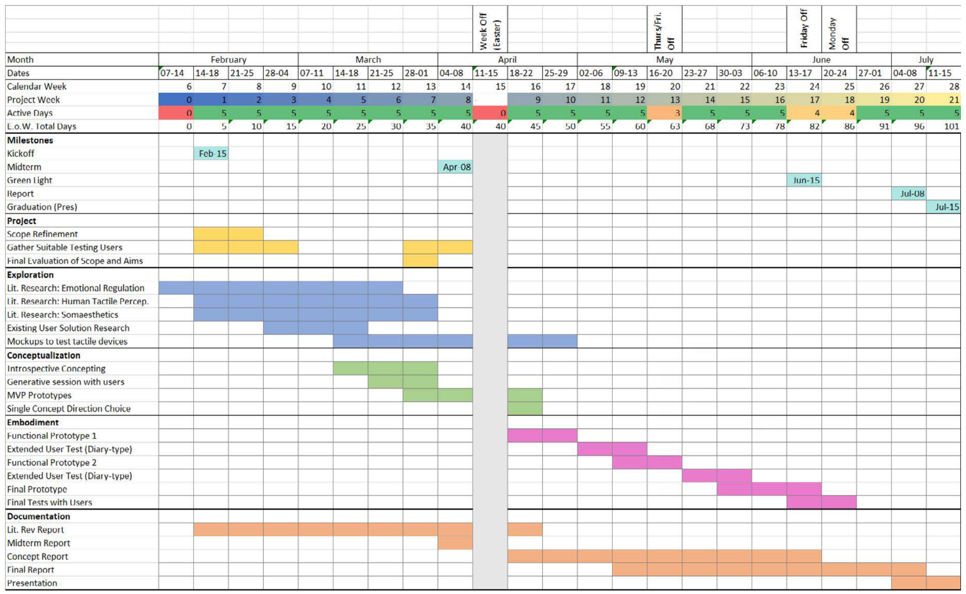
I am targeting a product that can be used by a single individual independently. However, if the process determines a social product is more suitable, we will pivot that direction. I am also targeting younger adults around age 18 to 40, especially those interested in “fulfilling experiences" or those that experience pervasive work and school related stress and anxiety. It is my preliminary belief that these groups will be most invested in this type of product and purpose.

It is also important that the "final prototype" is functional and achieves the set objectives. This may seem obvious, but often student projects fall short of a complete functional prototype for time or energy constraints, and this does not fit with the vision for this project. One final goal is that the project could, with a little additional work, result in a publishable case study of "soma design" in action.

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 15 - 2 - 2022   27 - 7 - 2022 end date



A few notes are necessary to fully explain the planned schedule:

First, this schedule is subject to change as it suits the evolving project. I have scheduled in multiple opportunities for longitudinal user feedback as I expect a product in this space can only be validated through intensive user testing (if we choose to base the product on external user feedback). Another option is to make the project significantly more "designer centric," and at that point the testing moments would be shortened and I would test with myself frequently.

Literature review and research are likely persistent and ongoing throughout the course of the project. However, at the start they will be the majority of my work and progressively tail off.

The project is structured in 3 successive stages: exploration, conceptualization, and embodiment. This is loosely based on the double-diamond model, with recognition that design should be iterative and incorporate the freedom to reconsider past decisions. We also incorporate plenty of time for the necessary deliverables.

This project has the potential to be highly technical (or technology-enabled), so that exploration and decision making will come before at at the midterm meeting. Overarchingly, I am proposing side-by side exploration of overall concepts directions with specific tactile devices, their produced sensations, and emotional responses.

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

Competencies:
This project is structured to round out my design competencies from my time at TU Delft. Most items have been learned by this time, and I wish to prove them in practice.

My elective coursework gave me opportunity to explore designer-centered and emotion-centered design methods which I found incredibly useful and appealing as an approach. I wish to prove those out in this project, especially as it relates to using abstract traits like emotion and "experience" to drive product requirements and development.

The ACD and AED projects helped me to structure my own time and plan necessary project steps, but each still had many benchmarks and checkpoints. This project will challenge me to actualize my own time management and planning skills. Those skills are to be "proven," but perhaps one that needs learned is intrinsic self-motivation without immediate deadlines or external motivation. Conducting work in the coronavirus era seems to be significantly more difficult for me, and I will be challenged to maintain my own motivation throughout the project.

The last skill to prove is as it relates to creative ideation and visualization of those ideas. Coming from an engineering background, ideation existed within predetermined constraints. Further, most ideas could be written and understood, or made in CAD. I have learned how to better communicate unfettered ideas through words, visual drawings, mockups, and more, and look to this project as an opportunity to show those skills in action.

Ambitions:
I simultaneous wish to have expert knowledge on topics that interest me, but never want to be pinned into a specific niche and to maintain my identity as an educated generalist. Thus, the first ambition I have is to dive deep into human tactual perception and understand how humans process touch as a sense and how we can be influenced by it. This includes literature on neuroscience but also on applied HCI work in modern smartphone tactile interfaces and the like.

The second ambition is to obtain a broad knowledge in many fields such as philosophy, anthropology, design, cognitive science, and programming. I believe all of these are necessary to create a well-rounded designer capable of leading innovation in a competitive business environment.

The third ambition is to develop products not specifically for commercial gain or to contribute to consumerist culture, but rather to create to improve human living. I recognize that there is no firm line between these product types, but it is a moral aim of mine all the same. Specifically, I would like to address the global south at some point, but not in this graduation project.

The fourth (and final) ambition is to return to one of my core skills of manufacturing and prototyping with this project. Due to our turbulent last few years, I have not had good opportunity to make use of the prototyping facilities at TU Delft, despite that being one of my deepest interests and favorite parts of the design process. I hope to showcase my abilities in this arena while also producing a very high-quality final prototype for the project.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

Thank you all! I'm excited for this opportunity.

I have appended a list of sources as the second image