Managing the Effects of Hyperhidrosis through Targeted Air Flow Application

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Augmenting Human Dexterity – Spring 2021
Term Project Report

Abstract

Primary Focal Hyperhidrosis (PFH) is an excessive sweating disorder that causes both physical and social discomfort. Many of the medical treatments for PFH have been determined to be ineffective or risky, but some ”at home” strategies to cope with the challenges of hyperhidrosis include controlling airflow to increase evaporative cooling. In an interview with an individual suffering from palmar hyperhidrosis, these strategies were communicated in addition to difficulty writing and social insecurity in school that arose from the condition. Using these insights, we hypothesize that a discreet assistive writing device incorporating induced airflow can reduce both physical and social discomfort for those with PFH. A functional prototype of this “vented pen” was built, incorporating a fan to increase airflow over the user's palm. To determine if self-reported comfort would improve with use of this device, a study is proposed where participants with PFH will write for a period of time using both a standard pen and the vented pen then express their comfort in surveys. If the hypothesis holds true, this work could motivate the development of assistive devices incorporating airflow as well as a potential large adoption of these devices that could lead to the destigmatization of sweating.

I. Introduction

Primary Focal Hyperhidrosis (PFH) is a condition that causes excessive sweating in localized areas of the body and may affect nearly 2.8% of the United States population [1]. Hyperhidrosis is an over activation of the body's natural way of cooling itself, sweating. This condition can have significant social, occupational, and emotional effects, in addition to impacting the ability to perform certain tasks [2]. Currently there exist a number of therapies to help treat the condition but there is no known cure and the cause also remains unknown. Unfortunately, the aforementioned therapies can vary widely in risk and success rate among individuals [3]. However, there are many opportunities for management strategies in addition to or without the use of medical treatments. For instance, individuals with or without sweating disorders know that wind is a critical part of cooling the body through the evaporation of sweat [4]. Having control of the airflow and environment can be extremely beneficial for those with PFH. This paper aims to explore the possible effects of using airflow as a method of alleviating some discomfort experienced through hyperhidrosis.

A. Background

Hyperhidrosis is a perspiration disorder that presents itself as excessive sweating of localized areas of the body. Most commonly these are the palms of the hands, soles of the feet, underarms or face [1]. Hyperhidrosis can be divided into two subcategories, primary and secondary. Primary hyperhidrosis is classified as excessive sweating in particular areas, but does not have a specific associated cause. Secondary hyperhidrosis refers to the same symptoms but is fundamentally caused by a pre- or simultaneously existing condition or disease. Since we are interested in addressing the symptoms of hyperhidrosis, this work primarily focuses on primary focal hyperhidrosis (PFH), specifically PFH of the hands [1]. Hyperhidrosis can range in severity among individuals. This severity is generally classified by the way the condition interferes with the quality of life of individuals and the discomfort they feel on a daily basis. There exist a number of metrics to qualify the severity of the disorder including the Illness Intrusiveness Scale, as well as the Dermatology Life Quality Index, developed at the Department of Dermatology at University of Wales College of Medicine [5] [6]. Apart from varying from individual to individual, the acute discomfort of the

disorder can also vary for a particular individual due to a variety of circumstances. Similar to individuals with normative sweat patterns, individuals with hyperhidrosis perspire even more than they already do, as heat, humidity, physical exertion and stress increase [7].

Types of Therapy: Although there is no known cure, there are a number of conventional therapies used to treat hyperhidrosis. These include injectable medications, surgery, topical applications, and oral medication. These therapies cover a wide range of effectiveness, risk, and cost [3]. The most commonly studied therapy is the use of botulinum toxin injections [8]. This therapy decreases the sweating of an area through a series of local injections that blocks the release of acetylcholine [6]. These therapies are often very expensive, carry a significant amount of risk and have a fairly low success rate. Although there are a variety of treatments, medical information about the disorder is still scarce and generally patients are disappointed by the information, or lack thereof, and treatment options provided by their healthcare providers [1].

Tangible Impacts: Functional challenges of hyperhidrosis of the hands center around the loss of secure grip that individuals have. Due to the layer of moisture on the skin, the friction coefficient is reduced and simple grasping or haptic tasks become a challenge [9]. Simple things such as holding on to something on a warm day, carrying heavy items, using a touchscreen, or doing delicate tasks can become impossible. These functional challenges affect every facet of life and can leave individuals with PFH feeling frustrated.

In research done by P. Kamudon, et al., it was shown that hyperhidrosis had an impact on subject's physical comfort, body odor, self image, confidence in interacting with others, choice of hobbies, being in public, personal hygiene, time and financial burdens, career choice and more [2]. This study also particularly highlighted the severity of the effect that hyperhidrosis has on functions performed at school or work. The specific activities reported to have caused significant frustration included, writing on paper, working on a computer or using machinery. A majority of the subjects in the study expressed that hyperhidrosis impeded their school or work performance and in fact a "majority regarded this as the most important impact of the condition [2]."

Evaporative Cooling: There is significant interest within the PFH community in alternatives to medical treatments for hyperhidrosis [2]. One overlapping area of research that has been extensively explored is the sweat patterns of endurance athletes and how these relate to performance. Sweating works to cool the body by secreting water containing energy in the form of heat. When secreted through the skin, this water evaporates and takes that energy away, cooling us down. The effect of healthy sweat patterns in athletes is critical because of the need to avoid overheating and worsening athletic performance. There is a large body of research that concerns itself with augmentative forms of cooling beyond sweat, as an effort to harness more physical potential out of athletes. It is within this area of work that the use of increased evaporative cooling by means of increased airflow have been studied. A greater airflow across the skin creates greater heat loss per unit sweat produced and the sweat rate for the entire body is reduced per unit time with this increased convection [4]. There is a lack of scientific information about how such increased airflow could benefit hyperhidrosis patients but we recognize that the work around athletes has significant implications for the management of hyperhidrosis.

B. Overview

We hypothesize that an induced airflow over the palmar region of the hands, in an otherwise draft free room, will improve the self reported physical and social comfort while writing on paper of individuals with hyperhidrosis compared to having no induced airflow. The increased airflow will not only reduce sweat dripping on paper and improve grip, it will also increase the evaporative cooling of the hand, reducing overall sweat production and further improving comfort. An interview with an individual with hyperhidrosis in Section II demonstrates the needs and challenges of those with PFH which highlight the value of airflow and the obstacles when writing as well as the social difficulties faced by those with the condition. To prove this hypothesis, we present an assistive writing device incorporating a fan in Section III which will allow us to qualitatively test the effects of airflow on the comfort of individuals afflicted

by PFH through surveys. If the hypothesis holds true, this research could have numerous impacts on studies and the development of assistive devices incorporating airflow as discussed in Section IV. As argued in Section V, these findings could have a much broader impact if the adoption of these devices became widely used outside of those with sweating disorders which could destigmatize the negative social implications of sweating.

II. Preliminary Results

To ensure the device would relieve some of the pain points of hyperhidrosis, we interviewed a young working professional with PFH. In performing this interview, we used a modified form of contextual inquiry, which requires the interviewer to observe the interviewee in the context of which a device or product would be used. Unfortunately, we had to use Zoom to conduct the interview so we had the interviewee guide us through some of their daily activities and how they overcome some challenges that may arise from hyperhidrosis. From this 90 minute interview, we gained many insights about the condition and elicited a multitude of needs that the device could address.

The interviewee has sought out medical treatments like oral medication or certain powder antiperspirants in the past which have had little to no effect. The interviewee was not interested in more invasive treatments like the use of botulinum toxin or surgery because of the potential risks and side effects. As a result, they have had little relief in the functional challenges of hyperhidrosis throughout their life.

This interview illuminated the need for a variety of interventions to address the physical and social aspects of this condition. It is clear that excessive sweating can have many social impacts especially for the interviewee who experienced hyperhidrosis not only on the palms but also in the armpits and feet. Specifically for palmar hyperhidrosis, the social impacts can range from not wanting to shake hands in a job interview setting to worrying about grade school classmates commenting on the ”clamminess” of their hands.

Additionally, many of the social discomforts may be accompanied by physical discomforts which could affect the interviewee’s ability to perform certain tasks. Because the effects of hyperhidrosis are augmented by situations that already cause sweat, like hot days or nerves, physical issues relating to palmar hyperhidrosis can worsen in those situations. School was a place where multiple of these situations could easily align. In college, the stress of exams, combined with the poor ventilation of the lecture halls can easily exacerbate the condition. In that situation, the interviewee would have to bring a blank note card to place their hand on when writing to absorb sweat and prevent the exam sheet from becoming over saturated with sweat. This could also cause stress, as the note card could be perceived as some method of cheating. In general, writing is a task that can cause many physical challenges. A pen or pencil can also cause a path for sweat to follow and drip onto the paper. In school, the interviewee would often have to use a tissue or sweater sleeve to collect the liquid. Pencils were preferred because they don’t smear like pens but simultaneously cannot write as well on damp paper.

The interviewee would utilize several strategies to reduce some of the symptoms or prevent some of the challenges of hyperhidrosis. The main strategy, when possible, would be to control the environment by using air conditioning or fans of various sizes in a room or on a desk near hands to help evaporate the sweat. While driving, they would point the air conditioning vents towards their hands to ensure they would have a good grip on the steering wheel. In other situations where a fan is not possible, the interviewee would fan their hands to reduce the sweat on the palms; however this is not ideal when many people are around. Altogether, increasing airflow was a critical strategy that the interviewee used to reduce sweating.

Overall, the interview was very insightful and these results only touch on a fraction of the needs that the interviewee may have. While the full list of customer need statements is in Appendix B-A, an abbreviated list that is relevant to the hypothesis is given in Table I. From the needs elicited, we believe an assistive device (AD) that utilizes airflow to aid with writing in a subtle manner can address some of the physical and emotional challenges of hyperhidrosis by improving comfort without drawing attention.

Customer Statements:	Customer Needs:
My sweat drips down my pencil and dampens paper	The AD catches the sweat before it reaches the paper
My palm resting on the paper dampens the page making it hard to write	The AD keeps the hand from touching the paper
I use fans a lot, both small ones pointed at hands and large window fans.	The AD needs to provide a draft of cool air in order to cool the hands
In school, I would worry about other kids noticing how clammy my hands were.	The AD needs to be discreet in order to not draw attention from peers.
Sometimes I have to decide when to tell people or not that I have this condition.	The AD needs to be subtle enough as to not expose the condition to others.

TABLE I: Key Customer Needs

III. METHODS

Device Concept: To test the effect of airflow on comfort while performing a task like writing, we have developed an assistive writing device that utilizes a fan to direct airflow to the palm in a discrete manner. As shown in Fig. 1, the vented pen is a writing tool that uses a small, quiet fan attached to the top to direct air through the center of the ballpoint pen and out of the holes on the side. Users grip this vented pen just as they would a typical pen, though it is slightly wider in diameter and longer overall. This vented pen will be used to evaporate sweat off the users hand while they write in order to prevent it from saturating the paper. This assistive device has the potential to make the experience of writing much more comfortable. Additionally, the small and quiet fan will allow the vented pen to be inconspicuous in social, professional, or school settings.

Subsystem description / proof of function: The components of the design can be seen in Fig. 2. The housing and the vent are custom 3D printed parts. Mounted to the vent is a button to turn the fan on and off. The vent is connected to the housing with a transition fit and is easily removed to replace the batteries. The entire pen length is about 200mm to accommodate the two batteries, the short ballpoint pen cartridge, the vent and the fan. Additionally the housing has an 11mm inner diameter to ensure there is enough room around the batteries for the air to flow. The holes in the housing are lined up on one side to direct airflow towards the palm, held as shown in Fig. 3. Fewer and smaller holes were chosen in order to produce stronger airflow. Future work will include optimizing the location of the holes.

The design presented here is meant to demonstrate a subtle design with a functioning fan. To fulfil this purpose, we selected a smaller fan (25mm) and powered it with 3V instead of the required 5V which allowed us to keep the design more compact. Due to these decisions, the strength of the airflow in the existing design is slightly weaker than intended. While this design provides an excellent proof of concept of a discreet assistive writing device incorporating airflow, we are considering other fans to be used for the proposed testing mentioned in the following section.

A proposed study: We will select 20 voluntary subjects to participate in this study. The 20 participants will cover a range of PFH severity levels as defined by the Illness Intrusiveness Rating Scale as well as ranging in age, sex and hand size. To participate, individuals must not have any of the following qualities: i) hands smaller than 6.8 inches from base of the palm to tip of the fingers, ii) inability to write at a level required to complete these tasks, iii) younger than age 16. These criteria were chosen in order to ensure the ability to use the pen and complete the necessary tasks.

The study will compare the experience of using the vented pen with airflow across the palm, with that of using a standard ballpoint pen, to write large amounts of text. In order to do this participants will have two 30 minute writing sessions, one with each pen. After each writing session participants will complete a survey. This survey is designed using a Likert scale and can be seen in Fig. 4. Because the results are qualitative, self reported and looking at something as subjective as “comfort”, the Likert scale is used to give some quantifiable measures to this qualitative data. The questions asked after the use of each pen are crafted so as to target the effectiveness of increased airflow over the palms in reducing discomforts

Fig. 1: Vented Pen Design

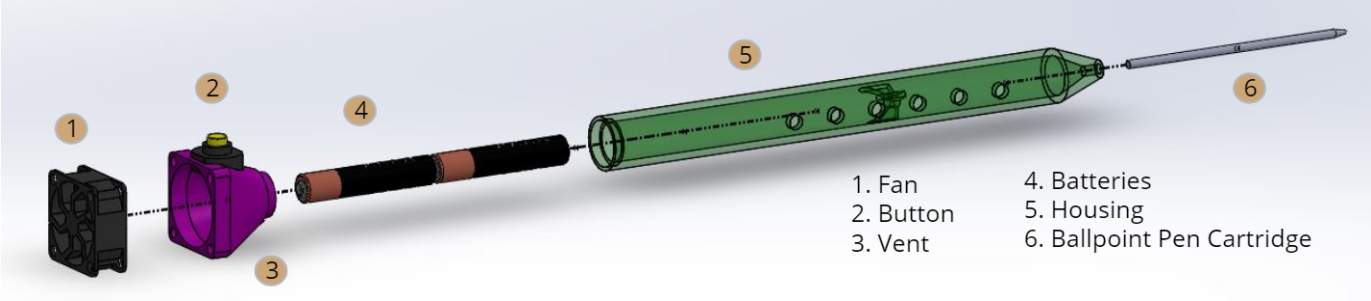

Fig. 2: Exploded View

due to palm perspiration. The purpose of the Free Response Survey Fig. 5 is to allow the subject to give feedback to the vented pen in their own words at the end of their entire study session.

Discussion of procedure /expected outcomes: Participants will arrive at the study office and be asked to take a seat in the room where a desk, chair, pen, lined paper, and text are provided. The participants will spend 10 minutes waiting in the room which is draft free and set to 70 degrees Farenheit, in order to acclimate. If the participants are testing the vented pen, they will be instructed on how to turn it on and that they should position the holes such that the airflow coming out of them is most comfortable and directed towards the palmar side of the hand. Then the participant will be asked to begin copying the text, writing continuously for 30 minutes. Once the 30 minutes of writing time are complete, that session will end. Next the participants will be allowed to leave the room if they choose and take a 30 minute break in cooler areas. It is during their break that participants will complete the "Writing Task" survey in Fig. 4. Following the 30 minute break, the exact same procedure, including completing the Writing Task survey again, will be followed for the second type of pen being tested. Finally the participant will complete the "Writing Reflection" in Fig. 5 after which they will be free to leave.

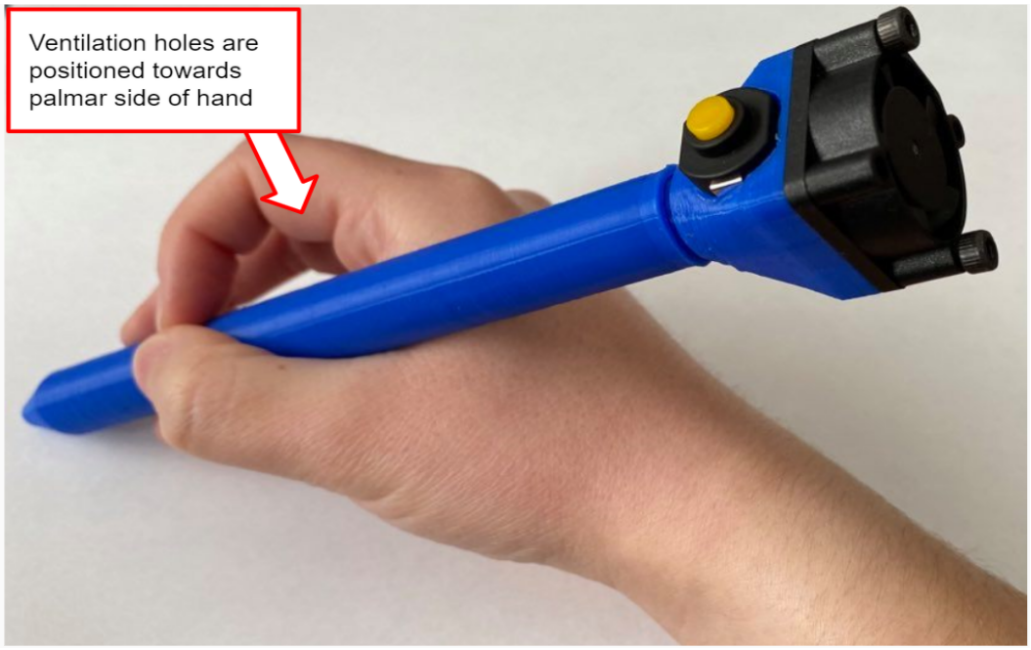

Fig. 3: Vented Pen Prototype

	(1) Strongly disagree	(2) Disagree	(3) Neutral	(4) Agree	(5) Strongly agree	(0) Not applicable
1. My hand was sweating during the writing task						
2. This pen made writing more comfortable than usual						
3. The air flowing out of the pen dried away my sweat						
4. The air flowing out of the pen cooled my hand						
5. This pen is similar to pens I usually use						
6. I enjoyed writing with this pen compared to pens I usually use						
7. I would use this pen at work						
8. I would use this pen at school						

Fig. 4: Pen Comparison Questionnaire

IV. Intellectual Merit

Through the proposed study and assistive device, we can demonstrate the impact of airflow on the comfort of people with hyperhidrosis. While there is certainly room for improvement of the design of this

1. Out of the two pens (regular and vented) you used today to complete the writing tasks, which do you prefer?

   a. Please explain why you prefer this pen.

2. Did the air flowing out of the vented pen dry your hands or keep them from sweating?

3. Did the air flow out of the vented pen cool your hands?

4. Was your hand sweating more or less when using the vented pen as compared to when using the regular pen?

5. Would you consider using the vented pen at school or work? (whichever is more applicable to you)

   a. Please explain why or why not?

6. On a scale of 1 to 10, 1 being not strong enough and 10 being way too strong, how strong was the airflow you felt across your palm while writing with the vented pen as it relates to comfort?

Fig. 5: Free Response Questionnaire

particular assistive device, this study can validate the use of airflow as a tool as well as demonstrate a need for assistive devices incorporating airflow in this particular space. Others in the academic community can test the impact of airflow in different assistive devices that target other situations, not only in ability to perform the task but in providing social comfort as well. Similarly, this validation can motivate those in industry to develop and market an assistive device for hyperhidrosis patients. However, this does require more studies and user testing to verify that the device truly addresses the needs of people with hyperhidrosis. These insights on airflow can also be incorporated in other assistive devices like prosthetics because comfort is an important factor in whether or not the assistive device will be used. With prosthetics specifically there is the challenge of providing cooling and sweat mitigation at the socket, the interface between the user and the prosthetic. This research has the potential to make an impact in multiple fields of academia and engineering.

V. Broader Impact

This study illustrates the potential for an assistive medical device which could have a significant impact on those with hyperhidrosis, a condition that is frequently underdiagnosed. Such a product could also be used by others who may not have the disorder or may not know if they have the disorder and simply want relief from sweaty palms. The larger adoption of this device by those who may not have sweating disorders can destigmatize many of the harmful social implications of excessive sweating. Additionally, the assistive device can be another method to provide relief outside of ineffective or risky treatment options.

Because the concept of this device that incorporates airflow is relatively simple, it has the potential to be adopted by the maker community to develop open source versions that can be replicated by others who may want the device. Overall, large adoption of these types of devices and de-stigmatization could be the most significant impacts of this research.

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APPENDIX A
INVESTIGATIONAL DEVICE DETAILS

APPENDIX B
COLLECTING AND ANALYZING INTERVIEW DATA

A. *Interpret the interview results*

Customer Statements:	**Customer Needs:**
My sweat drips down my pencil and dampens paper	The AD catches the sweat before it reaches the paper
My palm resting on the paper dampens the page making it hard to write	The AD keeps the hand from touching the paper
The condition is really bad in 100+ deg weather	The AD maintains or increases in effectiveness as the temperature rises
Pencils are sometimes nicer than pens because pens smear but you don't have to push as hard	The AD allows for any kind of writing device
I worry about hiking in the winter because my socks will get wet and it will be cold.	The AD prevents the sweat from causing cold feet
Although I don't sweat in my sleep I start sweating as soon as I wake up	The AD is available to be used first thing in the morning
I like to be in environments where I can control the climate	The AD can be regulated such as to accommodate for varying environments
Sometimes I have to decide when to tell people or not that I have this condition.	The AD needs to be subtle enough as to not expose the condition to others
I can't hold field work equipment out in the field on a warm day	The AD can maintain a grasp on slippery elements on a hot day, avoiding slipping and overheating
I wanted to be a doctor at one point but didn't think people would like the idea of me touching their body.	The AD needs to improve the experience of touching other people
Swimming was a very positive experience because I didn't have to deal with the sweat.	The AD needs to be easily removed for situations such as swimming
I wouldn't go on a hard bike ride without gloves.	The AD assist in holding onto handlebars or any sort of handle
I use fans a lot, both small ones pointed at hands and large window fans.	The AD needs to provide a draft of cool air in order to cool the hands
I sometimes only hold the steering wheel with a couple fingers	The AD allows the user to apply all fingers to the steering wheel or apply extra forces otherwise
I can not move heavy things such as furniture	The AD allows the user to firmly grip something heavy and apply their full strength
I can't open jars when my hands are sweating	The AD can open jars
I cant pull a tire off of a bike wheel	The AD provides the friction needed to apply force to a bike wheel and pull it off
I get electrocuted when I plug in devices	The AD needs to be non conductive
Bandaids wont stay on my hands	The AD needs to stick to her skin
I can't wear gray	The AD needs to not show sweat

Hierarchical list of primary and secondary customer needs:

- The AD avoids extra heat to the body
  - The AD is made of breathable material ***
  - The AD is made of sweat wicking material ***
  - The AD is kept off of the skin *
- The AD does not draw attention
  - The AD does not change color when saturated with sweat **!
  - The AD is not large if it is worn throughout the day *
  - The AD does not make loud noise *
  - The AD does not give off a poor smell **!
- The AD needs to provide grip
  - The grip needs to maintain its grip even when saturated with sweat ***
  - The AD needs to allow moving heavy items such as furniture *
  - The AD needs to allow holding multiple items **
- The AD is easily removable
  - The AD can be put on by the user themselves ***
  - The AD can be taken off by the user themselves ***
  - The AD takes less than 10 seconds to put on *
  - The AD takes less than 10 seconds to take off **
- The AD must work in all reasonable temperature conditions (10 deg F to 110 deg F)
  - The AD can not break below freezing
  - The AD cannot overheat below 110 deg F
- The AD is easily stored
  - The AD is easily fit in a purse or backpack *!
  - The AD is not sensitive to impact **!
  - The AD does not need special protective packaging to transport
- The AD is comfortable in the users hands
  - The AD should be usable in either of the users hands !
  - The AD should be assisting both hands

B. Brainstorming and solution generation

Fig. 6: Brainstorming

Themes of brainstorming session:

- Cooling off
- Harnessing strength from arms rather than hands
- Absorbent materials
- Increasing the traction of the hands with the world / allowing grip without slip

C. Converge on a single idea

Criteria	Weighting (1-10)	Absorbent Pencil	Friction Palm	Tire Tool	Hand Platform	Forearm Brace	Wrist Tool Holder	Sleeve Fan	Pencil Mount	Palm Barrier	Breathable Glove	Vented pencil
Avoid contact to body	10	0	-1	-1	0	-1	0	0	1	-1	-1	0
Cooling	9	0	0	0	1	0	0	1	0	0	0	1
Doesnt draw attention	7	1	0	1	-1	-1	1	0	0	1	1	1
Provides Grip	7	0	1	1	0	1	1	0	1	0	1	0
Easily Removable	5	1	1	1	1	1	1	1	1	1	1	1
Works in All Temps	3	1	1	1	1	1	1	1	1	1	0	1
Easily Stored	5	1	1	0	-1	0	1	1	1	1	1	1
Comfortable	10	1	1	0	1	-1	0	0	0	1	1	1
Feasibility	8	1	1	1	1	0	0	1	1	1	0	1
SCORE		**38**	**28**	**20**	**23**	**-12**	**27**	**30**	**38**	**28**	**24**	**47**
* Designs were ranked on a -1,0,1 scale. -1 meaning not, 0 meaning neutral, 1 meaning yes.												

Fig. 7: Weighted Matrix

Final Idea:

The idea that we converged upon from our weighted matrix scores was the vented pencil, a pencil with a fan attached to it that will blow air through the center and out holes along the body to help evaporate sweat from the users hand while writing. This device will make it easier for people with Hyperhidrosis to write without dampening their paper.

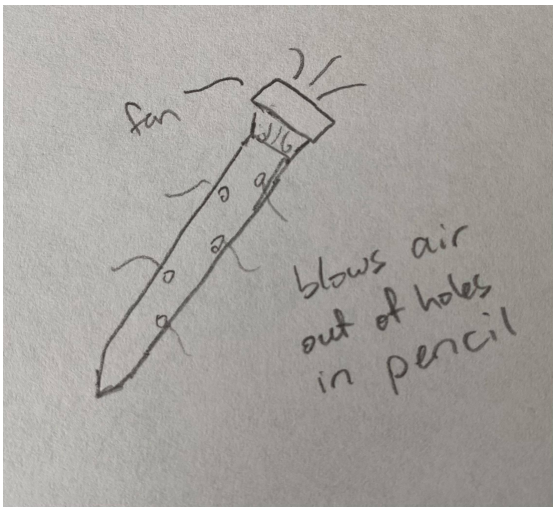

Fig. 8: Vented Pencil