HOW TO IMPROVE THE CANCER CARE QUALITY
- THE DEVELOPMENT OF THE EMOTION-FOCUS SUPPORTIVE SENSOR CHAIR
LCARE

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ABSTRACT

A fascinating fact of non-verbal language is that we can't always control our non-verbal language with consciousness. People use language to communicate in everyday life, but at the same time, we express what we want to say with our body and facial language too. In this way, the non-verbal language talks more about the truth. In some certain extreme conditions, for example, when people face life-threatening issues, people may even lie with what they say but still tell the truth with their face and body. Professionals of different fields have solved problems by reading the non-verbal language, like the FBI agents who will read people’s facial expressions to do the investigation. This is how I get the inspiration to make LCare, a sensor chair that can tell the true feelings of cancer patients. In cancer care, the doctor is still mainly understanding their patients through language but ignoring the gestures and body language expressions. This thesis proposes the medical design LCare to add the other communication layers between the doctor and the patient. LCare is an emotion-focus supportive sensor chair for the healthcare facilities, especially to help the doctors better understand the cancer patients by detecting the patients’ hidden emotions with pressure sensors and showing warning signals to the doctors and changing the environment lighting. The doctor may change the communication strategy based on corresponding color change on the armrests (red for shock, green for calm, blue for fear), and the environment lighting will change to purple when detected emotion of fear and thus calm the patient's nerve. The system of LCare contains the input and output parts and creates an immersive lighting care environment for the patients also. LCare helps collect the data from every case in the cancer care facilities and constructs the big database for the medical study.
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Dedicated to Lijin Zhang
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CHAPTER 1 INTRODUCTION

Oscar Wilde once said, "I don't want to be at the mercy of my emotions. I want to use them, to enjoy them, and to dominate them." I've been studying how to do emotion-centered design in my graduate study and focusing on how the five senses get information from the outside world. What intrigues me the most is no matter how hard we humans try to control our emotions; we are still not fully in charge of some part of it. As a designer, I design to help people feel the world better: I try to discover the potential of what a human is capable of and make the design that empowers the human capability. This thesis will show one of my explorations of the emotional design concept: how a chair design can provide emotional support from the doctor to the cancer patient and improve cancer care communication.

Based on my research, in cancer care, the communication between the doctor and the patient is critical but simultaneously got a challenging issue to solve. According to Thorne from the University of British Columbia, communication in cancer care is a recognized problem for patients. Research has provided limited relevant knowledge toward solving this problem. Patient accounts reveal 3 types of poor communication and in which "Systemic misunderstandings" are assumptive gaps between patients and professionals, which may be addressed through qualitative research. Furthermore, during my research in the Cancer Care Center of Decatur, after interviewed and observed 7 patients during their consultations with the radiation oncologist, the emotions of the patients' have changed from time to time, and patients hid their feelings until they burst out suddenly because they could not hold it anymore. Bridging the misunderstanding between the patients and the doctor is the pain point to solve. My design brief is to improve the cancer care quality by eliminating the misunderstanding of how cancer patients feel.
This paper will be divided into two parts, the definition of the design problem and the design process. The first part mainly discusses the problems existing in cancer care communication and why it became a problem, and then studies and discusses the possible directions for solving the problems; the second part mainly focuses on the design thinking on the directions obtained in the first part. The results of the first part of the exploration are integrated and transformed into a design product.

These two parts form a complete flow of design research and design thinking. I'll introduce the concept of emotional design and introduce the supportive design in medical design, which is the subsidiary of emotional design. Next, I will take the emotional problems of patients in cancer treatment as the object of research: why cancer can arouse extreme emotions in patients and need more emotional support in cancer treatment. which lead to the hypothesis of the low authenticity of the emotional response from the patients. And finally, after the interviews with patients and professionals, I came out with the solution of using body language as an indication to increase the authenticity of communication in cancer care.
CHAPTER 2 BACKGROUND: EMOTIONAL DESIGN IN MEDICAL CARE FIELD

Design is to solve the problem in the most proper way, and an industrial product design contains two main sections: function and aesthetic. Although the debate about whether function or aesthetics is more important is ongoing, a good design piece should balance them wonderfully. According to the investigation of Sylcott, Cagan and Tabibnia, when consumers decide, they will consider both a product's form and its function. Consumers employ a more complex decision-making strategy than when basing their decision on form or function alone. The researchers believe this strategy also involves both cognitive and emotional processes. Designers then pay more attention to emotional design to provide an even better product that balances function, aesthetics, and emotion.

Emotional design is the concept of how to create designs that evoke emotions that result in positive user experiences. To achieve a better and better user experience, emotional design is more valued today than ever by designers. Designers aim to reach users on three cognitive levels—visceral, behavioral, and reflective—so users develop only positive associations (sometimes including negative emotions) with products, brands, etc. The emotional design gives the product another layer of meaning and allows the users to see the function of the product and the value of having it. It is a way to approach human-centered design and achieve a more intuitive and natural result with empathy.
2.1 CONCEPT OF EMOTIONAL DESIGN

Emotional design is largely related to sensory design: the stimulus of external information will affect people's emotions, and the channels for receiving external information are our sense organs. First, our eyes as a visual organ undertake most of the information-receiving function, so designers conduct research and design on visual factors such as shape, texture, color, etc., to provide users with different visual languages and thus produce different emotional experiences. For example, when designing an indoor environment, designers use natural materials and plants. This kind of biophilic designed space can achieve a more relaxing effect and is widely used in the workplace to provide a more pleasant working environment. Fell's research (2010) indicates that seeing the wood grain reduces human stress levels: "wood provides stress-reducing effects similar to the well-studied effect of exposure to nature in the field of environmental psychology….wood may be able to be applied indoors to provide stress reduction as a part of the evidence-based and biophilic design of hospitals, offices, schools, and other built environments." Besides the obvious visual stimulation, our ears, nose, and limbs are also inititively or passively receiving information simultaneously, affecting our judgment of a product or an experience. The sound of a closing car door is the most well-known and frequently used example of a sensorial design approach. Maybe no one has ever actively asked to buy a car with a better closing sound, but the car manufacturer is paying a lot of effort to design the closing sound. In brand showrooms, consumers are not necessarily allowed to turn on the engine to judge a car's quality, but they can often open the door and try to sit in the car. Then the experience of opening the door is an important first step for consumers to form the first impression of the car. Many top automobile brands have separate door development teams, with
design engineers dedicated to fine-tuning their particular–signature–door-closing sound. This example of a sound design illustrates that consumer can easily accept the brand value with sensory design. Sensory design is one key that can shape a successful product in the consumer decision-making stage.

Emotional design theory can be used in many situations. Among all the applications, more designers are focusing on applying emotional design in medical facilities and devices. The theory of supportive design for healthcare facilities raised by Ulrich (1997) is one of the earliest and wide-used emotional design theories to provide a positive treatment experience for patients in medical facilities which becomes the theoretical foundation of the final design result, LCare.

### 2.2 SUPPORTIVE DESIGN: EMOTIONAL DESIGN IN MEDICAL CARE

According to Ulrich, the traditional medical design pays more attention to functional needs because of its particularity, leading to a very "hard" design of medical places and facilities. Ulrich keenly noticed the problems brought about by this function-led design: the tension brought by design directly hindered the patient's physical and mental rehabilitation process. Research has linked poor design to such negative consequences for patients as, for instance, anxiety, delirium, elevated blood pressure, and increased intake of pain drugs (e.g., Wilson, 1972; Ulrich, 1984). In the article of A Theory of Supportive Design for healthcare facilities Ulrich published in the Journal of Healthcare Design in February 1997, he mentioned that "design should do more than produce health facilities that are satisfactory in terms of functional efficiency, marketing, cost, and codes. Another critically important goal of designers should be
to promote wellness by creating physical surroundings that are 'psychologically supportive' (Ruga, 1989). Supportive design is designed to help drugs, and other treatments maximize their effectiveness and accelerate patients' recovery process. Designers should follow three main rules when design a healthcare facility:

Health facilities should not raise obstacles to coping with the stress, contain features that are in themselves stressors, and add to the total burden of illness. Instead, Healthcare environments should facilitate access or exposure to physical features and social situations with stress-reducing influences. Target groups should include patients, visitors, and healthcare staff. Ulrich emphatically discussed that stress is the biggest obstacle hindering the recovery of patients and proposed that the healthcare environment will support coping with stress and promote wellness if they foster:

- Sense of control
- Access to social support
- Access to positive distractions, and lack of exposure to negative distractions

Based on the principle of supportive design, I studied the facility environment and cancer care treatment process. I discussed and designed it to assist the treatment process according to the particularity of cancer patients.

### 2.3 CURRENT ISSUE IN CANCER CARE COMMUNICATION

My interest in cancer treatment and care originated from my personal story. My grandpa was diagnosed with advanced lung cancer eleven years ago. As the father of three children and an excellent rocket launch engineer, grandpa is a proud and responsible person, so he does not
allow himself to be weak and desperate. When facing his family's care and the care of medical staff, grandpa often hides his real emotions and pretends to be calm. However, this disguise made him irritable and sensitive to a certain extent and is also an obstacle to the medical staff to make accurate judgments about his condition. Now, grandpa has been gone for eleven years; still, the pain and torture he suffered before his death often made me think about how medical design helps treat cancer patients, especially the communication difficulties they have caused under extreme emotions. This is also the starting point for me to write this thesis. People will experience extreme emotions and need more emotional support when facing the shadow of death. Still, the cancer patients may choose not to show their anxiety and pain based on their personal dignity and social courtesy. Using emotional design to help medical staff understand the cancer patient's emotional needs and provide smoother communication is my graduation project and thesis focus.

Communication in cancer care can be critical in a positive clinical experience, but still a recognized problem for patients. According to Thorne (2013), 3 distinct categories of communication error correspond to differing degrees of poor communication from patients' perspectives. Thorne conceptualizes these as occasional misses, repeat offenders, and systemic misunderstandings. Here, the paradigm shows everything was done well while the communication isn't. Especially one example is the provision of excessive information in securing informed consent, and the clinicians fail to concern more about the patient's decisional and emotional support needs. Although the reasons that cause the misunderstanding can be complex, the patient's emotional needs are not visible enough for the clinicians should be considered the first motivation.
CHAPTER 3 QUALITATIVE INTERVIEW WITH THE PROFESSIONALS IN CANCER CARE

Based on the previous research and investigation, the communication problem in cancer care is a problem worthy of attention in the medical field. To better propose a solution, I created three in-depth interviews for the medical professionals in the cancer care system to get first-hand information about the cancer care communication problem. Unstructured or in-depth interviews (also sometimes called qualitative interviews) are so-called because they have little structure. I chose to do the unstructured interview rather than a standardized interview is because an unstructured interview gives the interviewees more freedom to talk about what they know so I can gain a 'rich picture' of what is happening. At the beginning of a design research process, it's better to know more about the user's needs, and the designer, him/herself, should not be preconceived.

The three interviewees are Nick Coddington, the clinical research team lead at Oregon Health & Science University; Anna Ji, the trainee nurse in Chicago; and Dr. Harold Yoon, radiation oncologist at the Cancer Center of Decatur, Illinois. The interview mainly consists of three parts: the first part, the basic information of the interviewee, mainly to understand the interviewee's work scene and nature of work; the second part, to understand the different work scenes and communication methods of the three professionals; the third part, also the most important part, mainly to understand how professionals can distinguish the patient's emotions and how to deal with them accordingly. The basic structure of the questions include:

1. what's your working process,
2. how the patient feels during the process,
3. how you communicate with patients, and when the patient is extremely emotional, what will you do.

3.1 INTERVIEW RECORD

The interviews aim to understand the overview of cancer care and narrow down the scope of my design application.

My first interview was with Nick Coddington; the clinical research team lead at Oregon Health & Science University. Mr. Coddington is an experienced researcher. His work is mainly to do the treatment research and match the best treatment methods to each patient. Therefore, an essential part of Mr. Coddington's work is communicating with patients about treatment methods and possible situations that patients need to face. In the work scene of Mr. Coddington, he often must deal with many extreme emotions from patients. Under this purely verbal communication scene, medical staff can perceive patients' emotional needs and are more sensitive to the emotional change of the patient. Through the interview, Mr. Coddington mentioned that he needs to strengthen his psychological construction because every time he communicates with the patient, the patient will have very extreme emotional fluctuations. Therefore, he needs to deal with it professionally each time and stabilize the patient's emotions. What's more, Mr. Coddington talked especially about how huge the workload that one professional may face every day, and the mood swings of patients happen all the time. Therefore, it is tough for every professional to give the proper emotional support and be sensitive all the time. Although Mr. Coddington mentioned that all the cancer care professionals have special training as a guide for
their verbal communication with the patients, as humans, his ability to offer emotional support to the patient is limited.

The second interviewee was Anna Ji, who worked as a nurse trainee in a hospital in Chicago. The work scenario of Ms. Ji is to communicate with hospitalized patients directly, including daily situation inquiries, support the changes in treatment methods, etc. In the interview, Ms. Ji mentioned how setting the physical environment helped her communicate with patients, especially in natural light. She mentioned that a large amount of natural light had become the main interior design element in current hospital buildings to help patients stabilize their emotions and improve treatment effects. And the nurses will assign regular sunshine hours to patients to alleviate their emotional problems. Through Ms. Ji, I confirmed the theory of supportive design mentioned in the previous article, supporting the treatment effect of patients through environmental design.

The third interviewee is Dr. Yoon, the radiation oncologist at the Cancer Center at Decatur, Illinois. As a radiation oncologist, Dr. Yoon needs to give patients a relatively complete treatment plan during the consultation. Therefore, for patients diagnosed for the first time, many experiences big mood swings during the consultation with Dr. Yoon. The most common way that Dr. Yoon gives emotional support is to stop talking, and let the patient digest the information for a period and calm the emotions. But Dr. Yoon mentioned a problem he faced: he was not sure when it would be more appropriate to stop the narrative. What he wants to achieve is to stop within the patient's tolerance. Because when the patient has emotional fluctuations, such as crying, the longer it takes for them to digest the information, making subsequent communication more difficult. Nevertheless, it is a challenging mission for doctors to recognize whether the
patient can still tolerate the information of their illness. Doctors must be both professionals and empathetic simultaneously. This has become a dilemma. If the doctor focuses more on professional communication, it is likely to ignore its emotional needs. Still, conversely, if the doctor is asked to provide empathetic support, it may go against why a patient approaches a doctor: seeking professional advice and treatment. Therefore, in Dr. Yoon's work scenario, assisting the doctor in providing patients with emotional needs on time without affecting the professionalism of communication and the effectiveness of information has become the key pain point.

3.2 DISCUSSION

Through the interview with the three professionals in the cancer care system, I clarified three key points in cancer care communication:

1. The daily workload of medical staff is huge, which will affect their effectiveness in providing emotional support

2. Existing medical facilities have the function of assisting medical staff in providing emotional support

3. Medical staff need device assistance to analyze and sort out the patient's emotional data

The first and second points all point to the third point. Because of the workload of the medical staff, it is impossible to ensure that the medical staff can give every patient the same attention and emotional support, and the cancer care experience received by every patient will be uneven. Although Mr. Coddington mentioned that they had conducted professional
communication training, as a person who also has emotional fluctuations, it is difficult for him to ensure accurate control of every detail. Therefore, an additional device that can provide reminders for medical staff becomes necessary. At the same time, the existing supportive design principles are more reflected in architectural design and interior design, and they are not widely implemented in smaller-scale applications, such as furniture, wearable devices, and medical devices. So in this thesis, my goal is to discuss the application of the supportive design principles on a smaller scale and apply it more in cancer care communication.

Based on these three points, I conducted on-site investigations and further interviews and observations at Cancer Center at Decatur, Illinois, and further refined the pain points in cancer care communication, and finally determined my design direction.
CHAPTER 4 RESEARCH DATA AT CANCER CARE CENTER OF DECATUR

The Cancer Care Center of Decatur supported my field research and allowed me to do the shadowing job with Dr. Yoon. I interviewed one cancer patient, one patient’s family, one social worker and Dr. Yoon, the radiation oncologist. I observed the facility of the entrance, the test rooms, the meeting rooms, and the treat rooms. I was allowed to record 7 first consultations of 7 different cancer patients. Based on these data, I was able to set up the design goal and exploring the possible way to use body language as an indicator to illustrate the patient’s emotion.

Figure 1. The entrance of Cancer Care Center of Decatur
4.1 THE BASIC INFORMATION

CCSI (Cancer Care Center of Decatur) provides comprehensive medical oncology, hematology, and radiation oncology services at the Cancer Care Center of Decatur. Diagnostic (bone densitometry and CT/PET scans), laboratory, and pharmacy services are also available. I focused mainly on the radiation oncology service of the facility.

The activity of the patient happens mainly in three parts of the building:

1. The reception and waiting zone

Figure 2. The entrance of Cancer Care Center of Decatur
2. The test rooms

Figure 3. The test room in Cancer Care Center of Decatur: patient’s chair and testing chair

3. The treatment rooms

Figure 4. The NMR in the treatment room
Patients undergoing treatment at cancer centers usually need to come to the cancer center every week, and some patients with severe illnesses need to be hospitalized. All patients need to undergo the first consultation to confirm the condition and confirm the treatment. This is usually the moment when the patient communicates with the doctor the most and the mood swings are greatest. Because even when they are prepared, the patient learns the severity of his condition in the first consultation. This especially includes many patients with advanced cancer who will learn about their very low cure rate and remaining lifetime. You can imagine the tremendous pressure and pain that people can't bear when you learn this information, so doctors will also be especially cautious in communicating this type of information. So, I made a key observation on the first consultation and found the existing problems to propose solutions.

Normally, the patient first makes an appointment with the cancer center and consults with the doctor at the agreed time. On the day of the appointment, the patient first enters the main building through the entrance and waits with the accompanying family and friends in the waiting area. The nurse will check with the doctor who has an appointment with the patient, prepare an independent test room, submit patient cases and other preparations; the doctor will prepare the patient's treatment plan, if necessary, especially when it comes to a combined treatment plan, in advance communicate with the attending doctors of other departments for the record. If the patient has a previous medical history or has other noteworthy conditions, the doctor will promptly communicate with other departments involved. After that, the patient and accompanying family members will be taken by the nurse to the nurse's station to take the height and weight measurement, and then confirm the basic information with the nurse in the test room, such as name and age, allergy history, and treatment history. Some patients with cancer
recurrence will also communicate with their previous attending doctors, and nurses will also establish corresponding medical records for different patients according to their personal needs. After that, the doctor will enter the test room, check the patient’s diseased part, ask about the current physical feelings, and communicate the treatment plan prepared in advance. This process usually causes emotional fluctuations. After that, the doctor will confirm the final treatment method. If necessary, the doctor will arrange for the patient to visit the chemotherapy in advance, watch the educational video, and understand the process of the treatment equipment.

I summarized the entire first consultation process as the following four steps:

1. The nurse will confirm the basic information of the patient, including the physical features, the medical history, and history of drug allergy,
2. The doctor will get the treatment plan first and then come to communicate with the patient and give the diagnosis
3. If the patient agrees with the treatment plan, the doctor will talk about the precautions,
4. The nurse will assist the patient in finishing the appointment of treatment.

According to the consultation process, the cancer care communication happens mainly in the test room, so I narrowed the design scenario to the test room.
4.2 TEST ROOM ENVIRONMENT SETUP

In the Cancer Care Center of Decatur, there are six test rooms with similar indoor facilities. The facilities equipped for doctors include a computer, a chair without a backrest, and an operating table with a sink.

Figure 5. The working area for the medical professionals
The patient can sit on an ordinary backrest chair and an examination bed with adjustable backrest angle. In addition, there are two ordinary back chairs for accompanying family members.

![Figure 6. The test bed and chair for the patients](image)

After entering the test room, the patient first sits on the back chair to communicate with the doctor and then performs a physical examination on the examination bed as needed. Therefore, in the entire consultation process, the chair is the furniture most frequently touched by patients. The observation has provided me the idea of redesigning the chair for the patient and transform this ordinary chair into some tool that can improve the communication between the doctor and the patient.
4.3 OBSERVATION RECORD

To further clarify the poor communication problem that occurs when the disease is diagnosed in the real scene, I observed the first consultations of seven patients. The following is my observation data.

Three of these seven patients had cancer that recurred in other parts of the body after many years, and four of them were diagnosed with cancer for the first time. Six of the seven were accompanied by family and friends, and based on my observation, whether someone is accompanied does not change the patient's mood swings. All seven of them developed extreme emotions during the communication link to confirm their condition, characterized by crying and uncontrollable shortness of breath. Among all the 7 first consultations, I recorded the video for one of the patients, Jack.

Figure 7. Jack's first consultation
Jack got throat cancer before, and this was his first consultation to get the diagnosis of cancer recurrence. The consultation happened in the test room at the Cancer Care Center of Decatur.

The consultation took about 30 minutes, and here is some period of video:

![Figure 8. Record of Jack’s body reactions](image)

![Figure 9. Analysis of Jack’s body language](image)
During the whole consultation, Jack tried to make jokes and show a relatively relaxed mood. But according to the observation and the video record, his body language tells a different thing. This inspired me to think about whether body language can be an effective sign to illustrate the inner emotion of the patients. Jack kept changing his sitting posture during his first consultation, especially when Dr. Yoon talked about his final diagnosis. Then Jack had shown a very obvious change in body language when the doctor told him that his cancer development was not optimistic. One of his hands tensely grasped the arm of the chair, the other hand kept rubbing his thigh, and his whole body tilted to the side holding the handle. In terms of facial expressions, he was still trying his best to keep calm at the beginning and maintain a normal conversation with the doctor. Still, his whole body was already very stiff, which was obviously different from when he first entered the test room. Suddenly Jack burst out into crying and started to ask how long he could still be alive. Dr. Yoon tried to deal with the situation professionally since obviously, he has been through a similar problem very often, and it took about 5 minutes for Jack to calm down. Later after Jack has left, Dr. Yoon said this is exactly the situation he wants to avoid and asked me to use design to improve this conversation that is destined to be hard.

After Jack's first consultation, I interviewed him individually. I asked him to recall if he was hiding his real feelings, and according to his answers, I created the customer journey map to compare Jack's true feelings with what he showed.
We can notice that the emotion that Jack showed to the doctor is not always what he really felt. This difference between the inner emotions and the externalized emotions is one of the main reasons why the patient doesn’t feel very comfortable during the communication with the clinicians. Doctors can only provide the most timely and appropriate emotional support when they understand the true emotional needs of the patient. So, the contradiction here is obvious: patients need to express more truthfully their emotional fluctuations to get the emotional support of medical staff, but for a capable social person, self-dignity is their principle and bottom line. Even in the face of painful torture and extreme sadness, most patients still abide by basic human social norms. When facing medical staff who are strangers that the patients meet for the first time, they are more inclined to conceal part of their true emotions and cannot fully reveal their hearts. Based on this contradiction, I have clarified the design brief: how to use design to let
medical staff understand the patient’s emotional needs in time without hurting the patient’s self-esteem.

4.4 DISCUSSION

The research at the Cancer Care Center at Decatur illustrates one of the main reasons that doctors can misunderstand the patient’s emotion is because people tend to hide their true feelings and be decent and polite in front of a stranger. This social culture of human beings can lead to a misunderstanding of the level of negative emotion. While hospital and medical facility is the place that people can ask for help, they still cannot trust the doctors and the nurses fully and talk about the fear they are facing. The goal here for me as a designer is to design a device that shows the patient’s true feelings to the medical professionals while respecting the patient’s privacy and dignity.

According to the data I collected, the chair in the test room plays an important role in the consultation. The patient will mainly sit on the chair while accepting all the information from the doctors. And when the patient sits in different positions, the body language can be the data that shows what’s inner emotion of the patient. Based on this hypothesis, I start the literature review to see the relationship between body language and emotions.
CHAPTER 5 LITERATURE REVIEW

So far, the design brief of this project is to use body language as the data to indicate the patient’s inner emotion, so the quality of cancer care will be improved, especially in patient’s emotional needs. I have done the literature review to understand the possible approaches. I’ve found some researchers have used a similar concept to understand people’s emotions in other circumstances like office setup and education setup. This research shows the bright future of using body language, especially the sitting position to visualize the inner feelings of people, and the technologies that these researchers have used are also valuable to my research.

In 2002, Selene Toledo proposed a system for the automated recognition and dynamical analysis of natural occurring postures when a child is working in a learning-computer situation. Toledo has built a static posture recognition system, a sensor chair that distinguishes the set of 9 postures and the overall accuracy is 87.6%. This system was used to demonstrate the affective state of children who were learning from the computer. This research shows the possibility of using posture to understand the affective state, which is the emotion we usually say.

![Figure 11. Experiment space](image-url)
Based on Toledo’s research, in 2012, Tatsuya Shibata and Yohei Kijima from Tokyo Denki University discussed the emotions of sitting postures. They took a side view of sitting postures as the evidence and analyze factors of the subjective interpretation by discriminating emotion adjectives.

Figure 1. Sitting posture samples in Experiments 1and 2

Figure 12. Sitting posture samples
In 2014 Sriparna Saha demonstrate how to use Kinect sensor to observe people’s body language and emotion:

So, the conclusion that I have is there’s a possibility to use the technology to “read” people’s emotions, and researchers have investigated the area for a long time. The sensor chair
built by Toledo inspired me to use a pressure sensor to collect the sitting posture data and transit it into the lighting signal with different colors.

Figure 14. Design concept
CHAPTER 6 CHAIR DESIGN PROCESS

After completing the basic understanding of cancer care communication and existing problems, the design process began. The industrial design generally follows four stages: ANALYSIS PHASE, DESIGN CONCEPT, DESIGN DEVELOPMENT, and IMPLEMENTATION PHASE. And because my graduation project does not involve the production part and focuses more on the preliminary research, the entire process, especially the first two stages, is subdivided into four parts: research and analysis, clarify the problem, propose different solutions. Design is not a linear process. It often involves continuous exploration and research in loops. Thus, in my entire design process, the two phases of the analysis phase and design concept are often repeated loops, and lead to the result. The design brief that I have is that there’s a possibility to use the technology to “read” people’s emotions, and researchers have been studying in the field for a long time. The sensor chair built by Toledo inspired me to use a pressure sensor to collect the sitting posture data and transit it into the lighting signal with different colors. But at the beginning of this project, I first established the goal of designing for cancer patients and then determined two design directions in the communication and research with different cancer medical staff: interior lighting redesign and mood visualization chair. Although my final thesis project can only complete one of the directions, the other design direction, the influence of interior lighting on my design, should not be ignored. I will briefly discuss how I came to the direction of interior lighting redesign and discuss how the research and analysis in this design directly contribute to the design of emotional visualization seats.
6.1 EXPLORATION

When I interviewed Anna Ji, who is working as an intern nurse at a cancer center in Chicago, she mentioned how her hospital uses natural light to accelerate the recovery of patients. They will provide patients with natural light for a fixed period each day as an auxiliary treatment in the rehabilitation program. With the aid of natural light irradiation, patients showed better mood and faster recovery speed. This gave me a lot of inspiration, and I started to explore the influence of natural light on the mood of patients. One of the important results was the discovery of Ulrich's supportive design principle. This report in 1997 clearly puts forward the shortcomings of the patient's emotional needs in the design of the medical environment and proposed three design principles to guide the design and construction of the medical facility environment. As I mentioned earlier, these principles are not only applicable to interior space and lighting design. Still, they can also be applied to smaller-scale designs such as product design, furniture design, etc. These small-scale design pieces can complement space design and work together on the patient's emotional needs. This supportive design principle has become the core theoretical basis of my design process.

Besides the supportive design principle, the case study with a huge impact on LCare is HealWell from the Philips Healthcare lighting program. This is also a case study based on the direction of interior lighting redesign. HealWell aligns patient room lighting automatically with our human circadian rhythm to help hospital patients sleep better, feel happier and heal faster. HealWell takes an evidence-based approach to light with ceiling modules simulating daylight rhythms with dynamic light levels and tones while providing excellent visibility for medical examinations. Patients can easily personalize lighting from their beds, while subtle LED
orientation lighting helps health workers navigate quietly. Studies show HealWell helps patients sleep more quickly and deeply, improving mood. The case study of HealWell gave me two critical points: one is that the design should be dynamic; another one is the environmental lighting should help calm down the patients.

![Figure 15. HealWell concept image](image)

Affected by psychological and physical, the patient's emotions are more sensitive and fluctuate than ordinary people. Some tiny details can also have a great impact on the patient's mood. And HealWell pioneered the practice of dynamic light to meet the dynamic needs of patients, using personal data as the basis for the design. It is a model that breaks the tradition that patients need to adapt to the hospital environment and has built a new model in which the hospital environment constantly learns to adapt to changes of individual needs. This is fully in
line with the supportive design principles, and it also adds "dynamics" as a keyword to my design philosophy.

When exposing to different environment, people will feel totally different. Especially when the ambient light color changes, the tone of everything in the environment will change. According to Plutchik’s Wheel of Emotions, people can visually group feelings:

![Figure 16. The diagram of emotions with corresponding colors](image)

And HealWell has designed different colors of ambient light based on the patient’s dynamic emotional needs in a day, creates a soothing environment. So, after the case study of HealWell, I added the ambient light color changing to my final design, explaining more in the later chapter.
I have got inspiration from interviews and case studies to help me finish the design in the exploration stage. Based on the supportive design principle and dynamic design principle, I have created the design concept, explained in the next section.

6.2 CHAIR DESIGN CONCEPT

The concept is to redesign the patient’s chair in the test room and use it as an indicator of inner emotion. There are several design principles here to follow:

1. It should be comfortable for the patient since most of the cancer patients are suffering from the pain of cancer side effect
2. It should use antibacterial materials since patients will reuse the test room every day, and the chair will contact the different patient
3. It should be adjustable since the body size of the patients can be varied
4. It should show the emotional signal clearly to the doctors but not visible to the patient. This is to protect the patient’s feelings and not to worry about his/her “performance” during the consultation. This is also for the authenticity of the data.
5. The overall design style should be caring and friendly to the patient. The CMF choice should help to calm down the patient rather than evoke fear in the medical facility.

In sum, the design is a sensor chair that can visualize the patient’s emotion, which transforms the patients’ emotion changes into LED light color changes for the doctor and the caregivers to understand, and at the same time change the ambient light color to comfort the patient’s nerves.
6.3 MOOD BOARD

Based on the previous research and concept, there are three keywords for the mood board: supportive, clean, and data driven. So, I researched some architecture design and parametric design to search for the potential design language:

Figure 17. Moodboard 1
Brainstorming is always critical for the designer to explore all the possible solutions and compare the advantages and disadvantages between them. My goal here is to find out as many possibilities as I can and figure out the most suitable way to solve the problem.

From the main design goal: design a device that can detect the real emotion of the patients; I created two paths to do the brainstorming. One way is to ask the patients to tell the real emotion, and they can write down the feelings or show a sign that can represent the true feelings. But I turned this idea down very quickly because first, it will spend extra time for both the patient and the doctor to communicate; second, when it involves active expression, patients may still tend to hide their feelings; finally, the consultation should be professional and smooth flow, and requesting the patients to write down their feelings may disrupt the flow.
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Another path to approach the goal is to understand the patient in a passive way, which doesn’t require the patient to do anything extra, the device will analysis the patient’s feelings and
communicate with the doctor directly. I decided to follow this thinking path because it respects patient’s dignity and body language is more reliable in the medical treatment situation. I researched all the possible body languages that we can read today and did the literature review to understand how the experts from different fields approach reading the body language. After comparing all these methods and inspirations, Toledo’s way of using a press sensor chair as the detection device is the most suitable. It will empower the chair furniture that every test room in the cancer care center will have with another function, make it smarter. It’s affordable and meets people’s existing habits. The patients don’t need to deal with some new strange device that they have never seen before. A chair design will not increase their sense of fear, neither will it add pressure to the upcoming consultation that is already very stressful.

As for the design language, I keep following the mood board I chose and did several quick sketches to find out the design that can balance the function and aesthetic. I try to use a curvilinear surface on the two handles to create an organic and elegant shape, which expresses the keyword: clean and supportive. And the textile on the handles, seat, and back will be created by the parametric design program as a highly unified part of the organic design language.

Figure 20. Sketches of LCare
6.5 FINAL SOLUTION

After the brainstorming and sketches, I came up with the final solution as LCare, the sensor chair design. LCare is an emotion-focus supportive sensor chair for healthcare facilities, especially to help doctors and cancer patients communicate by detecting the patients' hidden emotions with pressure sensors, showing warning signals to the doctors, and changing the environment lighting. The doctor may change the communication strategy based on corresponding color change on the armrests (red for shock, green for calm, blue for fear), and the environment lighting will change to soft purple when detected emotion of fear and can calm the patient's nerve:

Figure 21. Rendering of LCare 1
Figure 22. LCare with color signal

Figure 23. LCare changes the environmental light to purple
6.5.1 ERGONOMICS AND MEASUREMENT

The measurement of LCare: Width 713mm x Depth 426m x Height 838 mm.

It is comfortable for the patients to sit on since it’s wider than the normal chair. It also gives more support to the patients’ bodies because of its structure and handles design. The overall structure is flexible. When people move back and forth on the chair, it can always provide a moderate sense of support. LCare has two wide and curved handles surrounding the patient’s body; when the patient gets nervous, a handle is what he/she wants to lean to or grab.

Figure 24. Ergonomic consideration of LCare
6.5.2 FUNCTION AND WORKFLOW

When the cancer patients start to sit on the seat, the sensors start to work and transfer the pressure signals and accelerometer signals to the processor. Then the processor will analyze the synthesis of sitting posture, normalizes the data, and finally fuse and classify the feature. In this way, the chair can translate the signal into emotion and use some corresponding colors to warn the doctors (red for shock, blue for fear, green for calm). The doctor may change their communication strategy based on the emotion of the patients:

Figure 25. Workflow of LCare
According to Plutchik’s Wheel of Emotions, people can visually group feelings. The LED lighting signals show the corresponding color to represent the emotions that the patients have, and the professionals can understand them and adjust the communication strategy:
Figure 27. Instruction of color signal

- **Trust**
  1. Feeling secure or comfortable about the other, even if one is uncertain about the outcome of the other’s actions.
  2. A positive emotion that makes people confidently rely on the ability or integrity of the object of trust.

- **Rage**
  The state of being intensively and uncontrollably angry in response to something unjust, flagrant, or outrageous.

- **Grief**
  The emotional response to some adverse events like the death of someone or something to which an individual had an emotional bond or affectionate attachment.
LCare is a sensor chair that can detect patients' emotions by analyzing people's sitting positions. The textile pressure sensor and the accelerometer mounted on the back, seat, and armrests are the leading technologies that get the data from the chair. The processor is for analyzing real-time data. Two LED light strips mounted on the two armrests are for the light signal to warn the doctors. The Bluetooth technology helps the chair remote the environment lighting.

**Figure 28. Materials of each part**

**LCare_Materials**

- Textile Pressure Sensor
  - VHB+CNT Coating Cotton+Ni-Coated Textile

- Foam
  - High resilient polyurethane foam (cold foam)

- Armrest Frame
  - Polypropylene

- Adjustment Handle
  - Polypropylene

- Frame
  - Steel: Epoxy/polyester powder coating
Textile Pressure Sensor
The matrices capture the pressure body distribution of a person sitting on the chair. Using Gaussian Mixtures and feed-forward Neural Network algorithms, the system classifies the postures in real time.

Figure 29. Pressure sensor

CMF Selection

Figure 30. CMF selection
6.5.4 MODELING

I used Autodesk Alias to build the basic structure of LCare, and created an organic pattern with Grasshopper in Rhino 3D:

*Figure 31. Autodesk Alias modeling*
Figure 32. Handle modeling with Autodesk Alias

Figure 33. Generative design concept of textile
6.5.5 CANCER CARE COMMUNICATION WITH LCARE

LCare works as an important indicator for the professionals to understand the emotions that the patients are suffering. In that case, the professionals can adjust immediately their communication strategy, the ambient light will change the colors too to create a more comfortable environment.

Figure 34. When LCare shows red, it means the patient is shocked
LCare is like a communication assistant who can help the doctor to understand the patient’s emotional needs. It’s effective by communicating with the color signals, so neither the patient nor the doctor needs to stop the consultation. LCare follows supportive design principles and understands the property of human beings’ dynamics. It helps the consultation work smoothly but at the same time with more empathy from the medical professionals.
CHAPTER 7 WHAT’S NEXT

LCare is the first step to improve the communication quality in cancer care. It attempts to apply generative design to the medical environment. Although it takes about ten months to finish the research and design process of LCare, there is still something more to do.

First, I’ll put the real test from the cancer patients with LCare’s prototype to refine the design itself. I’ll figure out the questions like what’s the best color to warn the doctors and the nurses and what’s the best ambient light color to comfort the patients with these tests.

Second, LCare aims to become the device that can dedicate to a big database. The healthcare facilities can store the data collected from the LCare chairs to get the necessary information to improve the cancer care process. Also, the new data collection can be helpful to medical research.

Finally, the data collected by LCare can be the foundation for cancer care communication training.

I’m looking forward to the day that LCare can help real patients and make the medical treatment experience more empathetic.
REFERENCES


[2] https://www.interaction-design.org/literature/topics/emotional-design


