DESIGN AND DEVELOPMENT OF A SMART RING TO ADDRESS ANXIETY (INITIAL CASE STUDY AND MECHANISM REVIEW)

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Abstract. *Anxiety is one of the psychological conditions with a high prevalence in young adults, but the development of technological interventions that utilize tactile stimuli as a distraction is still limited. This research aims to design, build, and conduct initial effectiveness tests of a Smart Ring as a non-pharmacological technological innovation to help relieve anxiety. This research uses the Research and Development (R&D) method with a Waterfall model approach to the implementation stage. The trial was conducted through an initial case study on a student (N=1) who was identified as experiencing situational anxiety. Data was collected using the STAI-6 instrument to measure state anxiety before and after using the tool, supported by qualitative interviews to obtain user experience feedback. The results of the case study showed that the use of Smart Ring consistently lowered participants' anxiety scores in five different stress-inducing situations, with a score difference of between 4 and 8 points. The most significant decrease (8 points) occurred when participants faced the highest level of anxiety, i.e., during the final project proposal seminar. These preliminary findings present evidence that Smart Rings have the potential to be a functional and effective tool for the modulation of momentary anxiety, with a mechanism of action that can be explained through Attention Control Theory.*

Keywords: *Anxiety, Attention Control Theory, Design, Smart Ring, Vibration*

1. INTRODUCTION

Anxiety is one of the psychological conditions that can occur at various ages as a form of natural anticipation of feelings in the face of threats that are felt to be imminent (Novianti & Yudiarso, 2021). Clinically, anxiety can be divided into two forms, namely non-pathological anxiety and pathological anxiety or anxiety disorder. Non-pathological anxiety is adaptive, not excessive, still within reasonable limits, controllable, and can be postponed when the individual faces a more urgent situation. Meanwhile, anxiety disorder is a condition characterized by excessive worry, persistence, difficulty controlling, and lasting for a long period. This anxiety often appears without a clear trigger and can lead to significant disruptions in an individual's social, academic, and occupational functioning. One common form of anxiety disorder is Generalized Anxiety Disorder (GAD), in which individuals experience constant worry about various aspects of life for no specific reason (Nisa, 2025). According to the Indonesian Health Survey, in 2023 the highest prevalence of depression symptoms will be found at the age of 15-24 years with the highest rate of 3.7% experiencing anxiety disorders, 1% adolescents experiencing depression, 0.9% experiencing Post Traumatic Syndrome Disorder (PTSD), and 0.5% experiencing attention-deficit/hyperactive disorder (ADHD). This happens in adolescents and is referred to as a critical period because at this stage, there are various major changes in the individual that require a thorough self-adjustment. Complex and challenging developmental tasks often create emotional imbalances and instability in adolescents (Winurini, 2025).

As one of the global problems, anxiety disorders have been extensively researched and have led to many efforts and approaches that can be used in overcoming anxiety

disorders, depending on who suffers from the disorder and the cause of the disorder. Efforts to overcome anxiety disorders can be done internally or externally. Internal efforts include stress management, strengthening spirituality, implementing a healthy lifestyle, and the individual's ability to recognize and control negative thoughts and emotions. Meanwhile, external efforts include social support from family and friends, consultation with professionals such as psychologists or psychiatrists, and following psychological therapies such as cognitive behavioural therapy (CBT) or administering medication as recommended by the doctor. However, efforts to overcome anxiety disorders can also be done with two therapy methods, namely self-talk Therapy and Music Therapy (Sari & Zulfikasari, 2025).

To overcome anxiety disorders, a sensory system-based approach involves not only auditory stimulation through music therapy but also includes stimulation of other sensory systems, such as the somatosensory and vestibular systems. Vibration therapy, for example, targets the somatosensory system by applying gentle vibrations to the body, which can stimulate the release of endorphins and help lower anxiety (Rusmawati et al., 2012). Efforts to treat anxiety disorders mostly target the human auditory system with music therapy, even though sensory vibration also influences anxiety disorders. (Rusmawati et al., 2012). However, the development of vibration technology to treat anxiety disorders is still rare. In this case, researchers are trying to develop tools that can overcome anxiety disorders that target sensory movements, such as vibration for all age ranges, especially adolescents. This research was conducted to design a ring-shaped tool as a technological innovation in overcoming anxiety disorders.

2. LITERATURE REVIEW

2.1 Vibration Therapy

Vibration therapy or vibration therapy has been around since ancient times and existed in the mid-19th century. Vibration therapy has two types, namely Whole-Body Vibration and Localized Vibration. Whole Body Vibration (WBV) is a full-body vibration therapy through a special platform where individuals stand, sit, or even perform light exercises. (Van Heuvelen et al., 2021). Localized Vibration (LV) is vibration therapy that targets specific parts of the body or limbs in motion, not the entire body (Shantakumari & Ahmed, 2023). An example is the application of local vibration in patients with severe disabilities, which in a study (Seco et al., 2015) Has been shown to produce a positive hormonal response, including a decrease in anxiety.

Vibration therapy provides an intense and diffuse, yet non-threatening, sensory stimulus that engages mechanoreceptors throughout the body and demands significant nerve processing (Ahuja et al., 2024). The vibration therapy mechanism works with “bottom-up” That means mechanical vibrations are applied to the body through a local platform or device then receptors in the skin, muscles, and tendons detect the vibrations and convert them into nerve signals that travel up from the spinal cord to key brain areas (Misrani et al., 2024).

In the context of relieving anxiety or Generalized Anxiety Disorder (GAD), vibration therapy has been the subject of several studies. Research conducted (Chawla et al., 2022) mentioned WBV stimulates the release of serotonin and dopamine in affective states and lowers the stress hormone cortisol (Seco et al., 2015). Recent research by (Sant DW et al., 2024) Performed on Individuals with Opioid Use Disorder revealed WBV therapy can significantly lower anxiety (daily score $p<0.000001$; HAM-A score $p<0.002$). So that it causes the results of the anxiolytic effects experienced as relaxation and reduced anxiety. However, the effectiveness of vibration therapy is fragmented and still in its early stages.

2.2 Attention Control Theory

Attention control theory or Attention Control Theory (ACT) is one of the most influential theories in modern cognitive psychology that explains the relationship between anxiety and cognitive performance. This theory was developed by Michael W. Eysenck since

1990 which was originally named Processing Efficiency Theory (PET), until 2007 the theory evolved into Attention Control Theory (ACT). This theory states that anxiety does not directly decrease performance but rather interferes with a person's ability to control their focus of attention. So that individuals are more easily distracted and have difficulty staying focused (Eysenck et al., 2007). In this theory, it is explained that the human attention system is the result of the interaction between two main systems that often compete, namely the Goal-Directed System (Top-Down) and the Stimulus-Driven System (Bottom-Up). Top-Down is intentional, for example, when a person consciously focuses attention on work, ignoring the conversations around making the brain system work focused because it requires cognitive effort. While Bottom-Up is accidental or automatic, for example, attention is automatically diverted to the loud sound of a fire alarm because the brain system operates fast and requires no conscious effort. Individuals who often feel anxious are often caused by the frequent times their attention is "drawn" by a variety of irrelevant stimuli, both internal (e.g., heartbeat) and external (e.g., small noises in the room), and have great difficulty maintaining focus on the task at hand.

Vibration therapy or vibration therapy works as a "distraction," or it can be called stimulus driven attentional capture. It is a well-documented psychological phenomenon in which a person's attention is allocated unconsciously and automatically to a stimulus, not because of intention or purpose, but purely because of the physical properties of the stimulus such as brightness, sudden movements, or sensory peculiarities (Anderson, 2021). The vibration mechanism is not a deliberate diversion or Top-Down, but it is a powerful and inevitable 'capture' of the Bottom-Up effectively harnessing the cognitive vulnerability created by the anxiety itself. This therapy is, in a sense, "hijacking" the attention system for therapeutic purposes. Research conducted (Kanai et al., 2012) Reinforcing the explanation of the 'capture' of attention due to vibrations throughout the body effectively leads to an almost total and inevitable takeover of the attention resource, making the diversion process very powerful and very effective in interfering with other cognitive processes, especially the worry and rumination that characterize anxiety.

2.3 Tactile Stimulation

The human skin, the body's largest organ, is not just a passive barrier, but a highly sophisticated sensory interface. The skin is equipped with a wide array of specialized receptors called mechanoreceptors, which are designed to respond to various forms of mechanical energy, including pressure, stretch, touch, and vibration (Inggriyani & Hidayaturrahmi, 2020). The mechanoreceptor has two important parts in detecting vibrations, namely the pacini corpuscle and the Meissner corpus. Specific vibration ranges and locations provide different results in specific populations, in the context of vibration therapy research conducted by (Tan et al., 2024) examined the effects of acute WBV at various frequencies (5 Hz, 15 Hz, 20 Hz, 25 Hz, 30 Hz, and 35 Hz) on heart rate variability (HRV) and brain stimulation. The results showed that a low vibration frequency of 5 Hz significantly activated the parasympathetic nervous system reducing brain stimulation. In the 5 Hz frequency range the Meissner corpuscle receptor is key to sensing light touch. Meanwhile, vibrations in the range of 20-35 Hz in principle activate the sympathetic nervous system and increase brain stimulation. This vibrational signal will travel through the dorsalis lumnicus, medialis column, through the spinal cord so that it reaches the medulla brainstem. The signal will be transmitted to the thalamus and cortex of the brain.

Vibrations not only calm the body but also encourage physical relaxation thus causing mental calm. The therapeutic feedback mechanism is a 5 Hz low-frequency vibration stimulus on the skin that passes on nerve signals to increase vagal tone so that the heart rate slows down and HRV increases (Fooks & Niebuhr, 2024). A high heart rate or HRV generally indicates that the nervous system can adapt flexibly to environmental and physiological demands. (Chung et al., 2021), while low HRV indicates a dominant sympathetic nervous system rather than a parasympathetic nervous system that

functions to keep the body in a relaxed state (Chalmers et al., 2021). The perception of the brain will sense a calm and safe state of the body, which reduces feelings of anxiety and worry.

3. RESEARCH METHODS

This research is a type of research and development (Research and Development) or RnD produces a specific product and tests the effectiveness of that product (Abadi, 2022). This research uses a Waterfall design approach. Waterfall is a software development method that follows a gradual and structured sequence of steps, such as a waterfall flow. Due to its linear and systematic system, this model is also known as linear sequential or classic life cycle (Syarif, 2022). This method is sequential, i.e., if one stage has not been completed, it cannot start the next. This approach consists of five stages, namely: needs analysis, design, implementation, verification, and maintenance (Octaviana et al., 2023). The author applies the Waterfall approach to the implementation stage. At the implementation stage carried out on June 20-27, 2025, in a single or initial case study, sample selection was carried out using purposive sampling. The purpose of implementation in a single or initial case is to present the design and development of innovative tools as proof of concept supported by established theories (Bravo & Austin-Breneman, 2023). The STAI-6 instrument is used to measure anxiety levels; the STAI-6 instrument is the gold standard in the psychological literature to measure anxiety level (Matheus et al., 2025). Over one week, whenever Participant A felt an anxiety level above 2/4, he activated the vibrating ring for 5 minutes. STAI-6 levels were recorded before and after use of the tool. Then, an analysis was carried out on whether there was a decrease in anxiety or not.

4. RESULTS AND DISCUSSION

4.1 Needs Analysis

The development of a tool requires a deep and focused understanding. This process begins with the analysis stage of user needs, which is a crucial step in determining the direction of tool development. The results of the needs analysis provide a clear picture of the features and functions that must be presented by the tool to meet the expectations and needs of potential users. Not only needs analysis, but this study also conducted feedback interviews with experts who have experience in dealing with anxiety patients. The recommendations resulting from this analysis were taken from the results of interviews with 10 people, with details of 6 students, 2 nurses, and 2 psychologists as described in Table 1, as a reference in ensuring that the developed tools can function optimally and by the specific needs of their users.

Table 1. Needs Analysis Results

Student	**Nurse**	**Psychologist**
1. **Effective use**: Students need tools that can easily relieve anxiety during activities such as presentations, art performances, and speeches.	1. **Sensory Features**: Nurses need tools that can reduce the patient's anxiety with sensory stimulation features such as vibration and sound.	1. **Instructional Features**: Psychologists recommend that, in addition to sensory features, instructional features such as guidance on regulating breathing to relieve anxiety.
2. ***Flexibility* dan *Portability*** Students need tools that are easy to carry around, small, and inconspicuous. It can	2. **Comfortable Design:** Nurses need a design that is comfortable to use by the patient to use and does not interfere with the	**2. Focus Shift Feature:** Psychologists recommend features that provide sensory stimulation in the form of comfortable vibrations and

be used anywhere and does not disturb others.	treatment or therapy provided by other medical personnel.	sounds to stimulate the autonomic nervous system to shift focus from negative thoughts and increase feelings of calm.
3. **Design** Students need digital tools that can be attached to the body, such as accessories in the form of rings, bracelets, and necklaces.		

4.2 Design Process

After the needs analysis, the researcher begins the design process with a tool question such as: "What are the characteristics that the user wants?" Researchers also identified similar tools in helping relieve anxiety. The purpose is to provide a view of previous innovations and incorporate the latest knowledge in relieving anxiety, such as research conducted. (Matheus et al., 2025) Create robots that can provide breathing processing instructions to reduce anxiety levels. Research conducted (Haynes et al., 2022) Creating a pillow that has haptic features that can relieve anxiety, research conducted (Chawla et al., 2022) Mentioning that devices that produce vibrations in the body can reduce depression, anxiety, and stress in students. The researcher combined expert recommendations with a literature study on tools that provide a calming effect through touch and help the development of mental skills, and the following ideas were obtained: a) Tools that help users practice breathing through sound, b) Tools that listen to positive affirmations from users, c) Tools that can provide sensory touch to the body.

To choose the best idea to develop, the researcher discussed with two experts from healthcare facilities who are experienced in dealing with anxiety patients. Both experts know how anxiety arises clinically and emotionally, as well as how to predict anxiety from brain conditions. The researcher also brought an example of the 3d design tool that when discussed in Figure 1.

Figure 1. Prototype Form Selection

The response of experts is more positive towards the ring model than the smartphone because of several reasons, namely the smartphone model is considered the same as the general smartphone and seems too striking because the user wants the convenience of confidentiality and is more recommended in the form of an application than a tool if the design of the smartphone, according to them the sensory stimulus in the form of vibrations placed on the finger can give a more noticeable effect because there are many nerve endings there, Vibration ring can act like CBT (Cognitive Behavioral Therapy) patients focus on physical stimuli to divert panic attacks.

4.3 Network Systems

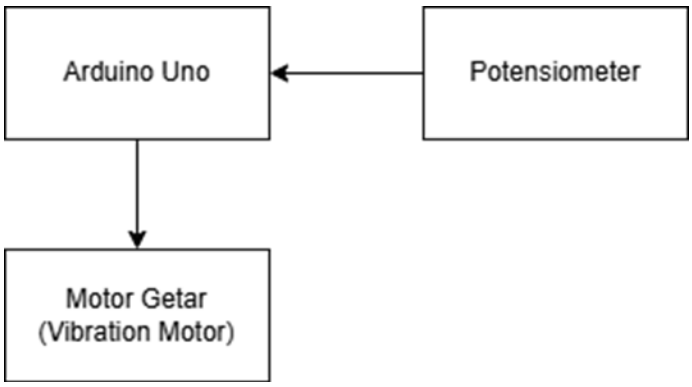

Figure 2. Block Diagram System

In Figure 2. The smart ring system starts from a potentiometer as a button, which will then activate the current component to 3-5V to supply the voltage needed for other components. So that it is channeled to the main component of the Arduino Uno module to regulate the work of other components, namely the vibrating motor components, to produce systemic vibrations. The circuit scheme of each component on the smart ring can be seen in Figure 3.

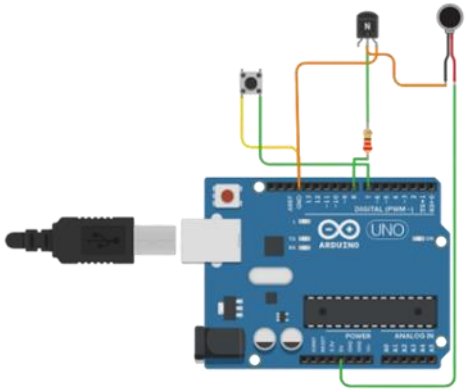

Figure 3. Hardware Networks

4.4 Interface Design

The process of creating interface design begins with the preparation of an initial concept in the form of a ring designed to accommodate hardware components according to the needs of the system. In Figure 4, the design of this ring is made using Blender software, a 3D modeling software, to produce accurate visualizations of shapes and dimensions. This ring is equipped with a button that can be pressed by the user. When the button is pressed, the vibration of the motor installed inside the ring will generate vibrations, which are passed through the aluminum lining of the ring.

Figure 4. Smart Ring Interface

4.5 Black Box Testing

Black Box Testing is a type of software testing that focuses on ensuring problems that can arise on the device when used by users (Hamzah, 2019) in (Abdillah et al., 2023). Testing is performed on system features. Based on Table 2, Black Box Testing shows successful results on all features tested.

Table 2. Black Box Testing

No.	Features Tested	Skenario	Expected results	Test results
1	Manual vibration trigger	The ring vibrates with a standard intensity and duration of 5 Hz for 5 minutes.	Vibrating ring	Successful
2	Vibration intensity	The vibration intensity can be adjusted from minimum to maximum via the trigger button.	The ring vibrates with low to high intensity, i.e., 1Hz-10Hz	Successful
3	Battery indicator light	The white light indicates a full battery, while the white light flashes a sign of a little remaining battery.	The indicator light shows white when full and flashes when there is little left.	Successful
4	Power on/off button	Press the power on button to turn on the ring, and the off button to turn off.	The ring turns on/off according to the function.	Successful
5	Battery charging	A micro-USB connection can charge the battery	The ring is charged with a flashing light indicator.	Successful

Based on the results of the Black Box Testing in the table, all features tested on the device showed performance that matched its function and successfully achieved the expected results. The test includes five main aspects, namely manual vibration trigger, vibration intensity setting, battery indicator light, power button (power on/off), and battery charging. In each scenario, the device shows the right response, such as the ring vibrating according to the intensity, the indicator light working according to the battery status, and the charging process running normally. All tests were declared successful, indicating that the main functions of the device have been performed optimally according to specifications.

4.6 Initial Case Studies

Participant A was a 21-year-old male. Participant A is a student at a state university in Malang, currently the participant is in semester 4. Participant A is located in Oro-oro Dowo Village, Klojen District, Malang City. Participant A said that he often experienced anxiety during lectures, such as before presentations, before exams, and during final project guidance. Participant A revealed that in the near future, a final project proposal seminar session will be held and must provide one last guidance to lecturers. Participants were found to experience anxiety with signs expressing fear and worry that the research proposal hearing did not pass and had to be repeated.

The implementation of the tool begins by explaining the purpose and objectives of the research, the description of the smart ring, the relationship of smart rings to relieve anxiety with attention control theory, and the steps in using the tool. The researcher explained the purpose of the STAI-6 instrument and how to use it. When participant A felt anxious in certain conditions were required to fill out the STAI-6 pretest and then use a smart ring for 5 minutes, then fill out the STAI-6 posttest.

Table 3. Anxiety Evaluation Results

Date	Skor STAI-6 *Pretest*	Skor STAI-6 *Posttest*	Score Difference	Information
20-6-2025	17	13	4	Final Project Report Guidance
22-06-2025	19	12	7	Preliminary Study at the Health Center, interview with the health center officer
23-06-2025	16	11	5	Preliminary Study at the Second Health Center Continues the Interview of the Remaining Officers
25-06-2025	17	11	6	Offline consultation with the supervisor questions the PPT proposal seminar.
27-06-2025	22	14	8	Final Project Proposal Seminar

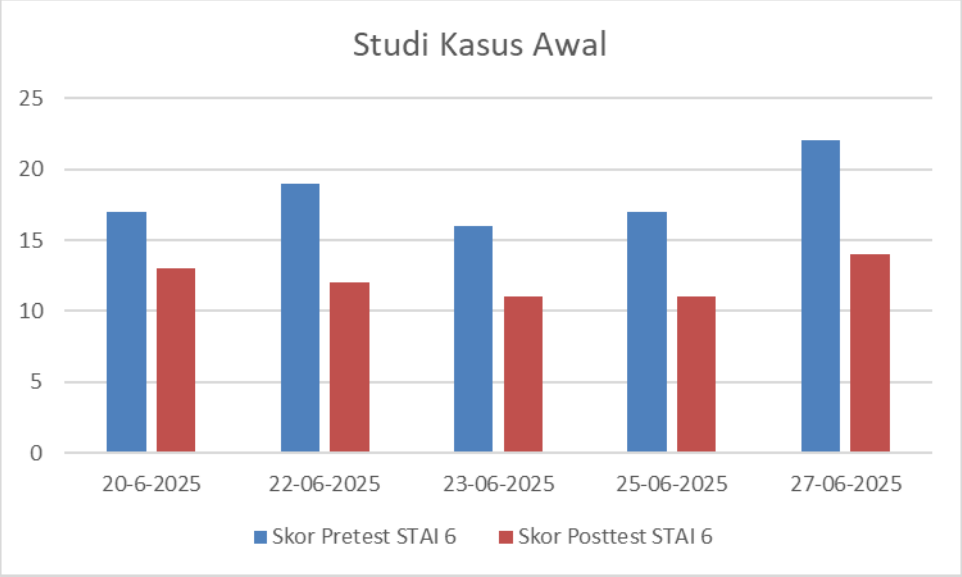

Figure 5. Pretest and Post test Score Bar Graph

The results of the evaluation from the initial case study showed that the use of Smart Ring consistently had a positive impact on reducing participants' state anxiety levels. Based on measurements using the STAI-6 instrument, there was a decrease in anxiety scores in each of the five stress-triggering situations observed during the period from June 20 to 27, 2025. Before the intervention, participants' anxiety levels varied from

moderate scores (16) to very high (22), which arose from various relevant triggers such as final project guidance, preliminary study interviews in the field, to consultation on proposal seminars. After the use of the tool over a specified period, the post-intervention anxiety scores consistently dropped, with the difference in score decline ranging from 4 to 8 points.

The most significant findings from this case study were during the peak anxiety moment, which was when participants faced the Final Project Proposal Seminar. At that time, participants recorded the highest pretest anxiety score of 22. It is precisely in this high-stress condition that Smart Ring shows the greatest effectiveness, by successfully lowering the anxiety score by 8 points to 14. This indicates that the effectiveness of the tool is not only limited to mild to moderate levels of anxiety but is also very pronounced at the time when psychological distress reaches its peak.

The researcher conducted a brief interview to find out Participant A's experience while using the Smart Ring. The initial use of this device occurs during the guidance of the final project, namely at the finalization stage of the research instrument. Participant A reported nervousness before meeting the supervisor because he was the only student who had a tutoring schedule that day. He is worried that if he gets a revision, it can delay the preliminary study schedule and his opportunity to attend the proposal seminar. According to Participant A, Smart Ring managed to divert his anxiety so that he could focus more. He explained that the sensation of low-frequency vibrations was quite effective in relieving his feelings of anxiety for a moment.

Similar experiences continued on the first and second days of the preliminary study, which involved interviews with health center officers. Participant A again felt anxious, especially since this was his first research experience. He reported repetitive behaviors such as going back and forth to the bathroom before the interview, which can be a sign of anxiety disorder (Cabeldue & McGlinchey, 2020). To minimize their anxiety, participants again used the Smart Ring and declared the results satisfactory. According to him, the device can provide vibrations at a higher level according to his needs at that time.

The peak of device use occurred during the proposal hearing. Participant A uses the Smart Ring for 10 minutes while reviewing the presentation material. For him, this distraction proved effective in relieving anxiety ahead of the session with the examiner, while also helping him focus on mastering the material. The results of this interview strengthen the researcher's belief about the relationship between tactile stimuli on the fingers and the theory of attention control, as in line with the research of Kanai et al. (2012). The physical vibrations that the body feels can effectively shift focus away from worry and rumination, which are hallmarks of anxiety.

Overall, this data presents strong preliminary evidence that Smart Rings are a functional and effective tool for modulating momentary anxiety in relevant contexts.

CONCLUSION

Based on the results of research and development, it can be concluded that the Smart Ring prototype, designed successfully, serves as a non-pharmacological aid to relieve momentary anxiety. The results of the initial case study showed that the use of Smart Ring consistently lowered momentary anxiety scores (measured by the STAI-6 instrument) in participants in various stress-inducing situations, such as academic tutoring and proposal seminars. The greatest effectiveness was recorded when participants experienced peak anxiety levels, which indicates the potential of this tool in conditions of high psychological stress. These findings support the theoretical framework of attention control, in which the vibrational stimulus (tactile) on the fingers manages to be an effective attentional capture to interrupt the worries and ruminations that characterize anxiety.

However, it should be emphasized that this study has some significant limitations. First, effectiveness testing was only conducted in the initial case study with a single participant (N=1), so the generalization of the results is still limited. Second, this

prototype uses a Localized Vibration (LV) approach on the finger while most of the referenced literature studies use Whole Body Vibration (WBV). These different methods of stimulus application are likely to result in different physiological and psychological responses. Therefore, further research is urgently needed with a larger and more diverse sample count to validate the effectiveness of Smart Rings more broadly. Future developments could also explore direct comparisons between the effects of Localized Vibration and Whole-Body Vibration in the context of relieving anxiety.

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