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The Power of Materials: The Impact of Tactile Experience with Biophilic Materials on Women's Anxiety

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Abstract: Alleviating the prevalence of anxiety disorders in women is beneficial for sustainable reproductive health. This study discusses the potential role of tactile stimulation on emotion regulation based on touch therapy. It explores the effects of directionality and roughness of biophilic materials on adjusting anxiety by guiding women to interact with different Biophilic materials. The study covered 30 female subjects sequentially exposed to four raw materials. Heart and respiratory rate data were collected, combined with a visual analogue scale to assess tactile pleasantness. Materials characterized with high natural directionality and low roughness evoked pleasant emotions, and materials with low roughness were associated with modulation of anxiety states. Various tactile stimuli trigger associative memories and stimulate the sympathetic nervous system to modulate anxiety. This contributes to a deeper understanding of the link between anxiety mood changes and material properties, reveals potential factors affecting anxiety relief, and facilitates the management of anxiety symptoms in women in the future.

Keywords: Biophilic materials; tactile stimulation; anxiety regulation; touch therapy; Physiological indicators

1. Introduction

There are notable disparities between genders in managing anxiety [1]. Given the rising levels of anxiety and prevalence among females, concentrating on female anxiety issues holds immense importance for the health and reproductive safety of future generations [2]. When an individual feels threatened, the sympathetic nervous system is activated, resulting in physiological changes [3]. Sensations can continuously influence emotions and convey diverse signals to the brain [4]. Research has indicated that touch can mitigate the body's response to anxiety. One of its functions is the regulation of homeostasis, which assists in restoring biological functions to average values following acute disturbances in the body [5]. For instance, physical contact between spouses [6]

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and mothers touching babies can yield the same effect [7]. External human body stimulation through massage can elevate dopamine and serotonin levels while reducing cortisol in saliva [8]. Based on stress management in human physiology, individuals display more stable emotional expressions when appropriately engaging with Biophilic materials [9]. The development of touch therapy has concentrated on addressing the lack of human contact through animal companions or specialized textures and has aimed to enhance positive emotions in humans [10].

This study focuses on touch therapy, focuses on the influence of Biophilic materials on human emotions, validates the practical value of the tactile experience offered by Biophilic materials in regulating female emotions, and seeks to provide answers to the following questions:

i. What are the characteristics of haptic materials that reduce people's anxiety?
ii. Can interacting with various textures of haptic materials modulate women's anxiety?
iii. What are the primary factors that affect the emotional state of haptic materials?

2. Related work

2.1. Therapeutic Benefits of Touch Interaction

The emotional interventions used in touch therapy are based on multi-sensory experiences, such as visual and auditory associations, to stimulate the processing of brain memory and alleviate negative cognitive processes[11]. The response to tactile stimulus is rapid, leading to adjustments in hormone levels that promote healing of the body and mind, making touch therapy a practical application[12]. This method has gained recognition in the scientific community over the past four years[13]. Current practical applications focus on pet companionship research[14] and touch interaction provided by intelligent companion robots[15], while the positive healing effect of material properties is yet to be explored[16]. Scholars have demonstrated that tactile interaction can induce a state of flow and stabilize emotions[17], and different textures and colours of materials can elicit various feelings[18]. The practical application of touch therapy was initially validated in nursing homes and has since been extended to pain treatment in hospitals and rehabilitation facilities[19].

2.2. The impact of various Biophilic materials on humans

Using Biophilic materials in human society can increase comfort from nature and promote psychological health and emotional resonance[20]. Research on Biophilic materials mainly focuses on the stimulation of texture[21], roughness[22], fluidity, and colour [23] as research elements, with less research on the role of Biophilic materials in anxiety. Touch can evoke a genuine connection between people and nature[24], emphasising that materials similar to nature can enhance positive connections[25]. Reach in the literature describes anxiety reduction as a state of reduced physical and psychological tension, usually accompanied by a decrease in neural excitation[26], a decrease in sympathetic nervous system activity, and the production of pleasant and joyful emotions[27]. When interacting with different textures, heart and respiratory rates associated with the parasympathetic nervous system change[28]. McGlone found

a negative correlation between [29] pleasantness and roughness, stickiness, and a positive correlation with furry and silky textures, with emotional arousal positively correlated with roughness and hardness. Roberta found that touch is more arousing physiologically than vision, and rough textures can trigger the recall of negative memories[30]. The study focuses on the relationship between physical surface roughness and anxiety, exploring whether these two characteristics of Biophilic materials have an impact on the regulation of female stress.

3. Experimental

3.1. Experiment Design

Participants: Thirty female subjects were recruited openly within a first-tier city. Participants were all qualified as anxiety-prone female office workers (mean: 26.5 years ± 6.12) without psychiatric disorders, with normal cognitive functioning and normal tactile sensitivity. All participants gave informed consent.

Table 1. Sample structure of subjects.

	Type	Options	Frequency	Percentage (%)
	Gender	Female	30	100
A.	I am prone to anxiety, shortness of breath when I am stressed, and my heart races not being able to express myself adequately.	Yes	28	93.24
		No	2	6.76
B.	There is no physical tactile imbalance.	Yes	0	0
		No	30	100
C.	There are few opportunities in life to contact nature	Yes	27	89.91
		No	3	10.09
	Total	/	**30**	**100**

Environments and stimulation: The experiment was conducted in a 45 square meter soundproof space in Guangzhou, China. Warm lights were used, and the humidity and temperature were controlled to meet the comfort level of the human body to minimise the influence of other emotional factors on the experiment. Four types of Biophilic materials, ranging from large to slight roughness, were chosen for the experiment. They are artificial gravel, artificial wood, artificial moss, and artificial fur (Figure. 1). The materials all met the definition of pro-biophilic materials (Figure. 2) [31], and the ordering of material roughness was verified in three dimensions: material temperature, colour shade, and material granularity size[32].

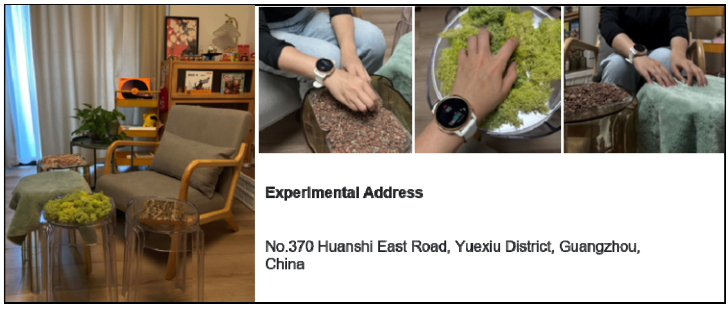
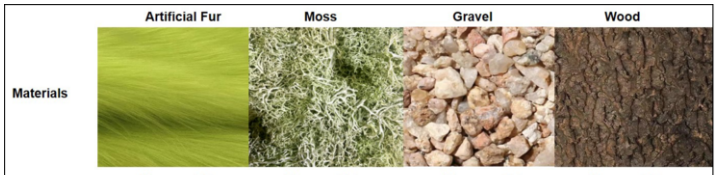


Figure 1. Experimental environment



	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Temperature	4.00	0.830	2.33	0.809	2.93	1.552	2.53	1.586
Color depth	2.90	1.296	3.23	1.278	1.96	0.657	4.63	0.482
Particle size	2.23	0.774	3.03	1.129	3.63	0.948	4.66	0.471

Figure 2. Experimental irritant criteria.

Data Collection: Negative responses are characterized by physiological arousal, and negative reactions are identified by prolonged physiological arousal or repetitive reactivation after removing the stressor[33]. To capture the rapid and subsequent effects of short-term anxiety indicators, the assessment period should be extended and supplemented with follow-up interviews. The experiment was conducted to introduce stress through the Stroop task [34], with the help of the Hamilton scale, to assess the subjects' anxiety fluctuations before and after touch. Finally, pleasantness was evaluated with the Visual Analog Scale, which has been shown to have validity for emotional feedback [35]. A semi-structured interview was used at the end of the session to allow the subjects to describe their feelings of touch.

Equipment: A professional Gamin 6 pro was used to measure participants' heart and respiratory rates during the experiment. Mainstream professional testing devices have been shown to measure primary physiological data reliably [36].

3.2 Procedure

Three measurements were performed during the experiment for labelling:
T1: baseline measures HAMD1 at the beginning.
T2: post-stimulus measurements after anxiety induction HAMD2.
T3: post-intervention sizes of touch materials HAMD-different materials.

First, the anxiety scores were completed after the stress was introduced through the colour task, and the participants touched the four materials to feel the stimuli back and forth, up and down. Each touch lasted 5 minutes, and the participant's heart and respiratory rates were recorded using wristbands during the experiment. At the end of the touch, participants assessed their feelings on a visual analogue scale that moved between the labels "unpleasant" and "pleasant." After a 2-minute interval, the following material was touched, and the scale was completed. Pearson's correlation and

ANOVA one-way analyses of variance were conducted using SPSS Statistics to examine the relationship between women's anxiety and pleasantness and the different materials (Figure. 3).

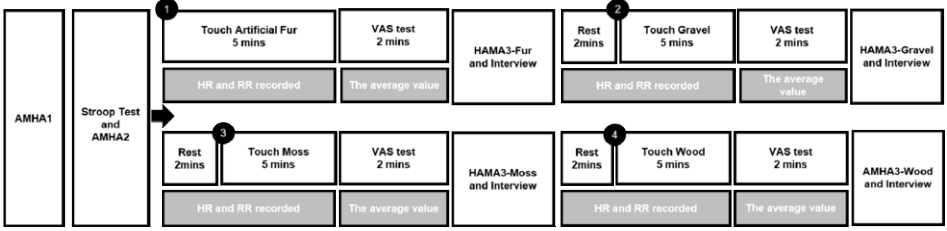


Figure 3. Experimental Procedure.

4. Results

4.1. Biophilic materials with strong natural directional properties impact the management of anxiety

Based on the results of the correlation analysis, we observed changes in the subjects' anxiety index and pleasure level after exposure to the materials. However, only fur ($p = .046$), moss ($p = .031$), and wood ($p = .002$) were found to be correlated with the change in anxiety index and pleasantness of the subjects (Table 2). This suggests that women could slightly adjust their anxiety levels when touching low-roughness wood and moss. Further interviews might uncover that the texture of the gravel was more bothersome and could elicit negative associations depending on individual differences. It is impractical for anxiety regulation, and excessive intensity may result in negative stimuli. Moderate roughness of the moss material was not linked to anxiety relief. Interestingly, touching the wood had little effect on anxiety levels and pleasantness. The findings suggest that materials with significant differences in roughness can partially regulate anxiety.

Table 2. Explanation of the correlation of pleasantness after touching the material

		HAMA02-pressure	VAS-Fur	VAS-Moss	VAS-Gravel	VAS-Wood
HAMA02-pressure	Persona	1	.046	.031	.314	.002
	Sig.		.602	.599	.086	.339

Moreover, Biophilic materials such as fur and moss significantly affect the physiological regulation of anxiety (Table 3). Specifically, respiratory and heart rates were altered in females after touching fur, indicating that exposure to soft materials associated with natural elements influences heart rate regulation (P=.034). Comparing mean heart rates after touching the materials showed that the smooth texture gradually calmed emotions and regulated respiratory rate (P=.047). Anxiety metrics before and after touch allowed for the observation that materials with high naturalness and low roughness had a complex relationship in anxiety regulation, and the specific effect requires further confirmation through additional experiments.

Table 3. Analysis of physiological indices after touching the fur

		Square sum	Df	Mean square	F	Significant
RR-Artificial Fur	Between-group	56.325	7	8.046	.778	.047
HR-Artificial Fur	Between-group	148.010	7	21.144	.958	.034

In addition, there were changes in human physiological indicators after coming into contact with mossy materials (Table 4). Contact with soft textures in nature, such as grass, loose vegetation, and potted greenery, could moderately affect the respiratory rate of women (P = .036). However, it did not have a significant effect on adjusting the heart rate (P = .179) based on the changes in anxiety indicators before and after contact. This low roughness, high-pointing pro-natural material can positively influence changes in women's anxiety states, although the differences are not statistically significant.

Table 4. Analysis of physiological indices after touching the fur

		Square sum	Df	Mean square	F	Significant
RR-Artificial Moss	Between-group	38.567	7	5.610	.267	.036
HR-Artificial Moss	Between-group	286.167	7	40.881	1.632	.179

4.2. Low roughness biophilic materials can enhance pleasure

Gravel (VAS-M = 40.1) and wood (VAS-M = 56.77) can cause significant changes in heart rate, but they bring lower pleasure ratings, possibly due to their rough texture, causing discomfort. In contrast, fur (VAS-M = 6.61) and moss (VAS-M = 9.03) pleasure ratings indicate a clear sense of comfort due to their soft texture. In addition, analysis of variance shows that changes in pleasure when touching wood have a significant impact on subjective anxiety levels. However, despite the minor difference in roughness compared to tree wood (Table 5), the effect of gravel on pleasure is not significant (Table. 6). In conclusion, gravel can have a more substantial effect on physiological changes, possibly due to irregular gravel textures triggering various past experiences in women, resulting in more or less harmful visual and emotional responses.

Table 5. Single-factor analysis of physiological indicators after touching the wood

		Square sum	Df	Mean square	F	Significant
VAS Test-Wood	Between-group	682.083	6	113.781	.675	.025
	total	4557.560	29			

Table 6. Single-factor analysis of physiological indicators after touching gravel

		Square sum	Df	Mean square	F	Significant
VAS Test-Gravel	Between-group	1077.778	7	153.968	1.181	.353
	total	3946	29			

5. Discussion

The preliminary findings of this study revealed the impact of different roughness and Biophilic materials on women's anxiety. In cases of significant roughness variations, it was observed that low-roughness materials could evoke pleasurable feelings, while materials causing noticeable physiological changes are not conducive to regulating anxiety levels. Rough materials are prone to triggering negative associations [37]. The results indicate that high materials focused on naturalness can regulate anxiety levels; they can not only regulate anxiety but also evoke pleasant feelings. There is a strong correlation between smoothness and pleasantness, enabling people to associate with broad and warm images, which helps in mental relaxation.

Furthermore, the relationship between anxiety assessment and pleasure in high naturalness and low roughness material combinations is apparent. As the pleasure assessment gradually increases after touching, reaching a steady heart rate, the average heart rate of touching gravel (M=98.2bpm) is closest to that of tree wood (M=102.71 bpm), triggering a robust physiological response with a lower index of physiological pleasure. Conversely, the average heart rate of touching fur (M=88.22 bpm) is lower, but the pleasure index is higher. This indicates that the subjects believe touching soft fur can evoke nature-related memories, which is consistent with prof Cavdan's research conclusion [38].

6. Conclusion and limitation

This study focuses on the potential impact of biophilic materials in regulating female anxiety, underscoring the essential role of biocompatible materials in anxiety management. It holds significance in addressing the psychological and reproductive challenges faced by women. The research findings indicate that women are more likely to experience pleasure when interacting with softer materials resembling natural characteristics. Physically, the study delves into the link between tactile stimulation, heart rate, and breathing responses. The results revealed that participants' past experiences influenced their reactions. This research could potentiate the correlation between material-induced tactile sensations and emotional regulation, contributing to a deeper understanding of the benefits and applications of Biophilic materials in touch therapy. It could also improve material classification and aid in developing touch therapy techniques. The limitations of this study are related to the narrow coverage of the surveyed population. The study initially focused on issues specific to the female population, with the hope that by first focusing on research findings related to female emotions, further support could be provided for research on male anxiety emotions—this oversight of the study's limitations complex to associate accurately with textures and emotion-related types. The research should focus on separating the impact of different roughness on the perception of emotional touch. Additionally, this study excluded the influence of visual recognition on emotional perception, and it is still unclear whether the combination of visual and tactile senses can deepen the perception of positive emotions.

Furthermore, this study lacked a more comprehensive approach to collecting physiological data. In the future, we aim to include measurements such as skin conductance and electroencephalogram (EEG) to explore further the psychological

processing mechanisms involved in touch therapy. The findings of this study highlight the potential of using various Biophilic materials in healing environments to alleviate anxiety, providing guidance for material selection in tactile therapy, and offering practical strategies for alleviating anxiety in specific individuals.

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