



FABRIC- AND TATTOO-EMBEDDED MICROSYSTEMS FOR MGBA-MIND RELATED HEALTH RESEARCH

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KEYWORDS :

I. INTRODUCTION

Fabric- and tattoo-bedded systems can be used (a) for body and brain health and (b) in a smart-home for controlling smart home devices [1]. Current healthcare approaches, for most ailments, seem to focus on treating the symptoms rather than the root cause of many diseases leading to a worldwide rise in health problems related to the brain, mind and MGBA (Microbiome-Gut-Brain-Axis). Further health problems can result due to side effects of prolonged use of prescription drugs.

To study the mind as algorithms based on data generated in MGBA and its role in health conditions/problems one must consider factors related to Behavior, Exercise, Environment and Diet (BEED) that, in a complex manner, affect stress and chronic inflammation levels. Consequently, the root cause of most diseases/conditions is an extremely complex problem involving mind as seen in Fig 1.

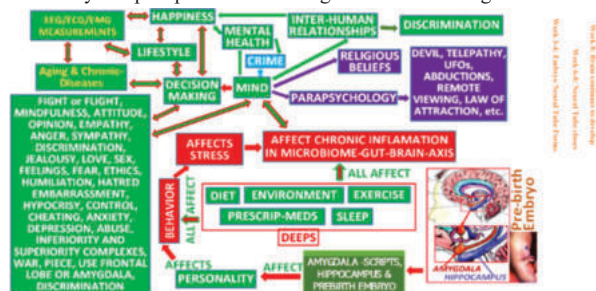


Fig. 1 A detailed mind model affected by pre-birth, amygdala and hippocampus memories. Embryo brain development occurs during weeks 3-9 of pregnancy.

II. Mind Role in Human Happiness. Health and Problems/ Diseases

Role of mind in chronic inflammation and health issues is explained in Fig. 1. Mind of a human depends on three childhood memory factors; pre-birth, amygdala and hippocampus memories that affect all health and happiness problems. Mind can also help solve health problems depending upon childhood memory factors. Brain's goal is survival, and it occurs along Microbiome-Gut-Brain-Axis (MGBA). Brain can raise blood pressure if needed and it cannot control human decisions which are controlled by human mind.

III. Inter-Related Health Factors

Chronic inflammation is the major cause of all health problems. It can be affected, positively or negatively, by BEED (Behavior, Exercise, Environment and Diet). While stress affects chronic inflammation directly, the behavior (normally affected by pre-birth memories, amygdala scripts and hippocampus memories) is the major factor, called mind, affecting stress.

Normal inflammation is body's self-healing response to kill damaging agents and is crucial for survival, particularly to cope with acute inflammation during the human reproductive years. The chronic exposure to a variety of antigens induces a chronic low-grade inflammatory status (so called 'inflammaging') that contributes to age-associated morbidity and mortality [2]. The key to successful aging and longevity, for all ages, is to decrease chronic inflammation without compromising an acute response when exposed to pathogens. This is because in later life, chronic inflammation can lead to a number of chronic diseases such as atherosclerosis [3][4], type 2 diabetes [5][6], Alzheimer's disease [7], multiple sclerosis [8][9], and osteoporosis [10][11]. Major depression and frailty (common in the elderly) have a major inflammatory component [12][13].

The fact that chronic inflammation can occur in any part of the brain

and body makes the research on Fabric- and Tattoo-embedded Inexpensive Biomedical Microsystems (FTIBM) more complex. For example, recent research shows that chronic inflammation problems can occur anywhere along the Microbiome-Gut-Brain-Axis (MGBA) [14][15][16]. As the gut is the longest and most complicated body part (one of the three body parts along with skin and lungs directly exposed to the outside environment), understanding the implications of its exposure to the outside world and related chronic inflammation is a huge challenge. For example, the antibody immunoglobulin (Ig) is involved in food intolerance (IgG) and food allergies (IgE). IgG, the most common antibody in circulation in human blood (approx. 75 %) [17], causes Irritable Bowel Syndrome (IBS) and other problems because certain foods have antigens incompatible with IgG [19]. Also, the emotional problems [17], mediated by amygdala scripts [18], hippocampus and pre-birth memories [20], become dominant because the PFC (pre-frontal-cortex), being a newer part of the brain, is more susceptible to psychological and physiological cognitive damages [20]; particularly for elderly [22] health.

Recent research shows that lectins, found in whole grains, nuts, beans, lentils and grain-fed animal meats, can also affect the MGBA causing a number of health problems [23]. Lectin avoidance diet [23] claims to alleviate the following health problems; aching joints, acid reflux or heartburn, acne, age spots, skin tags, allergies, alopecia, anemia, arthritis, asthma, autoimmune diseases (including autoimmune thyroid disease, rheumatoid arthritis, type 1 diabetes, multiple sclerosis, Crohn's, colitis, and lupus), bone loss (including osteopenia and osteoporosis), brain fog, cancer, canker sores, chronic fatigue syndrome, chronic pain syndrome, colon polyps, cramps, tingling, and numbness, decline in dental health, dementia, depression, diabetes, prediabetes, insulin resistance, exhaustion, fat in the stool (due to poor digestion), fibromyalgia, Gastro Esophageal Reflux Disease (GERD), Barrett's esophagus, gastrointestinal problems (bloating, pain, gas, constipation, diarrhea), headaches, heart disease, coronary artery disease, vascular disease, hypertension, infertility, irregular menstrual cycle, miscarriage, irritability and behavioral changes, Irritable Bowel Syndrome (IBS), low counts of immunoglobulin G, immunoglobulin M, and immunoglobulin A, low testosterone, low white blood cell count, lymphomas, leukemias, multiple myeloma, male-pattern baldness, memory loss, migraine headaches, nutritional deficiencies due to malabsorption (e.g., low iron levels), Parkinson's disease, peripheral neuropathy, Poly Cystic Ovary Syndrome (PCOS), skin rashes (including dermatitis herpetiformis, eczema, and psoriasis), slow infant and child growth, unexplained bouts of dizziness or ear ringing, vitiligo, and weight loss or weight gain.

IV. Fabric- and Tattoo-embedded Inexpensive Biomedical Microsystems (FTIBM) Research

This section focuses on (a) holistic approach to collect mind/body data using FTIBM (Fabric- and Tattoo-embedded Inexpensive Biomedical Microsystems) and smartphones, (b) thousands of years old meditation and herbal therapies and remedies that tend to cure the cause of health problems without the side effects, (c) the latest research on self-healing and (d) algorithm development to predict/confirm the health problems listed above. The research reported in this paper has the following unique features:

- (i) Education and understanding of effects of aging and meditation/herbs to study how aging affects the brain/body health through age-related cognitive impairment of PFC.
- (ii) Fabrication and testing of 24-hour-wearable Microsystems (FTIBMS) to upload brain/body data to a smartphone.
- (iii) Studying how exercise, food, herbal remedies and environment can affect elderly wellbeing as monitored by wearable systems mentioned in (ii) above and

- (iv) Educating the current generation as well as preparing the next generation with smart tools and apps available in hand and easy economical food habits to add grace and safety to their aging process.

Single-sensor-EEG (electroencephalogram) BIMS (Biomedical Inexpensive Micro Systems) embedded in a cap, wig, jacket and shirt collar were successfully tested. While BIMS are mostly based on off-the-shelf components, the use of a sewing machine to fabricate 80-micrometer-thick Cu-wire-based EEG sensors as shown FTIMS in Fig. 2 (b) is one of the innovations of this work. The cap-mounted BIMS led to design and testing of a mind-controlled robot [24]; a technology applicable to FTIBM for in-home brain/body health monitoring using smartphones (useable in smart-homes).

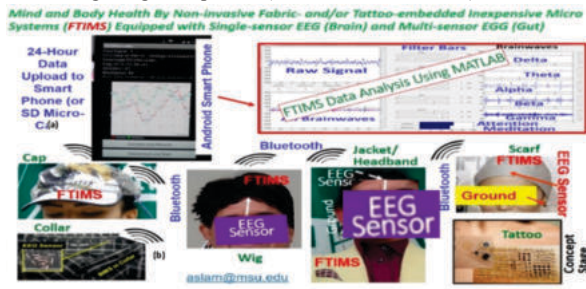


Fig. 2 Single-sensor-EEG BIMS embedded in a cap, wig, jacket, shirt collar, scarf or tattoo. Data upload to and analysis by smartphone.

V. Innovations in Health Research

The health research focuses on herbal remedies, reflexology, meditation, self-healing, MGBA, innovative new diet programs and health-related creative algorithm development.

The fMRI (functional magnetic resonance imaging) scans are being used to monitor the efficacy of stress-reducing Yoga meditations [25][26]. With the availability of smartphone apps and inexpensive wearable biomedical devices the efficacy of Yoga and reflexology therapies [27] can be monitored. Smartphones and FTIBM (Fabric- and Tattoo-embedded Inexpensive Biomedical Microsystems) will be used to monitor the efficacy of anti-inflammatory herbs such as coconut, hemp seeds (a variety of the Cannabis sativa plant species), curcumin (an important ingredient in turmeric) and black seeds (nigella sativa) that have been the subject of hundreds of recent studies because of their effectiveness in curing chronic inflammation-related mind and body health problems.

The new exciting research on (a) slowdown of telomere-related cell division [28] that is possible through the control of environment and (b) activation of sleeping stem cells, if awakened, can reverse the aging [29] because these reveal remarkable benefits for the elderly if the stress, environment, exercise and diet are managed properly. FTIBM (Fabric- and Tattoo-embedded Inexpensive Biomedical Microsystems) equipped with EEG/ECG/EMG (Electroencephalogram/Electrocardiogram/Electromyogram) sensors can be used along the MGBA as adults of all ages are susceptible to MGBA inflammation-related health issues. This study will use smartphones and MUSE-2 to acquire and process MGBA data on 24-hour basis.

Algorithms for the prediction of depression [30] and other health problems (important for in-home healthcare of elderly and others) have also become focus of recent research. Algorithms development, which requires data collection and storage, is a long-range goal of this research to predict possible elderly health problems through in-home health monitoring using smartphones and FTIBM (Fabric- and Tattoo-embedded Inexpensive Biomedical Microsystems).

The research reported in this paper has the following unique features using smartphones: (a) education and understanding of effects of aging and meditation/herbs on how aging affects the brain/body health through age-related cognitive impairment of PFC, (b) fabrication and testing of 24-hour-wearable Microsystems (FTIBM) to upload brain/body data to a smartphone, (c) monitoring how exercise, food, herbal remedies and environment can affect elderly wellbeing as monitored by wearable systems mentioned earlier educating the current elderly generation as well as prepare the next generation with smart tools/apps available in hand and easy economical food habits to add grace and safety to their aging process.

VI. Understanding Aging Effects on Elderly Decision Making

Human decision-making affecting health and aging depends on mind

which depends on prebirth, amygdala and hippocampus memories. To understand how the brain/mind works and why an impaired or partially impaired PFC could be a major problem for the elderly consider this example. A human having a walk in the woods makes a sudden turn and spots a curvy object on the ground. How does the human mind decide whether this object is a threat, an opportunity or neutral [31]? In the first few tenths of a second after the object is sighted, a visual signal, entering the occipital cortex of the brain, is transmitted to (a) hippocampus (for a quick evaluation by comparing it to objects on its danger list) and (b) to amygdala which promptly communicates with PFC (that performs a sophisticated analysis) and other parts of the brain. Even if in this example, the object turned out to be a stick, the mind must go through all the necessary processes to decide whether freeze or flight is required.

Although, the reaction to situations like one mentioned above will be similar for all human beings in general, the elderly mind may simulate the 'fight, freeze or flight' behavior even for normal situations due mainly to age-related sensitivities including phobias/fears of getting (i) diseases, (ii) hurt, and (iii) anxiety/depression generating unnecessary stress. The PFC is most sensitive to the detrimental effects of stress exposure [32][33][34]. This is because the PFC, the most evolved brain region with the highest-order cognitive abilities, is more susceptible to impairment in contrast to older subconscious limbic system of the brain (with amygdala and hippocampus being the emotional centers). Even quite mild acute uncontrollable stress can cause a rapid and dramatic loss of PFC cognitive abilities while a prolonged stress exposure causes architectural changes in PFC dendrites [32]. Consequently, amygdala and hippocampus mediated, or emotional behavior can dominate undermining the role of PFC.

Recent research has begun to reveal the intracellular signaling pathways that mediate the effects of stress on the PFC [32]. It has provided clues as to why genetic or environmental insults that disinhibit stress signaling pathways can lead to symptoms of profound PFC dysfunction. However, the environmental effects dominate according to "genes load the gun, the environment pulls the trigger" [35].

How can the performance of PFC be made more effective to counteract the negative influence of Prebirth, Amygdala and Hippocampus (PAH) memories which affect mind of elderly? It is interesting to note that in a normal breathing process only medulla is involved, and PFC plays no role. Yoga and meditation exercises with carefully designed breath-in and -out cycles involve activating PFC's role in relaxing [25][26] and minimizing PAH's stressful/emotional role. The involvement of PFC can help eliminate the false positives for the 'fight, freeze or flight' response.

The educational, informational and testing methods, proposed in this section, will range from layman-type approaches to complex hands-on demos that can relax the elderly mind by the activation of enhanced PFC role. A novelty of this research is that (a) easy and simple yoga exercises can benefit the elderly and (b) simple food proposals will enhance their abilities to do these exercises and yoga.



Fig. 3 Jacket-embedded BIMS for brainwave data upload into a smartphone (a) and a Cu-wire EEG sensor design (b).

VII. Exciting Educational Demos

Starting with informational sessions/videos of biomedical LEGO-based toys [36][24], the effects of meditation/Yoga on mind relaxation and focus level were demonstrated by showing brainwave data uploaded to smartphones similar to data shown in Fig. 2 but using off-the-shelf toys.

VIII. Sophisticated FTIMS Demos

Starting with the brainwaves demo shown in Fig. 2 the quantification of attention and meditation levels shown on a smartphone, apps for complete spectrum of brainwaves and raw data can be developed. A unique feature of the EEG sensor is the use of sewing machine to embed the sensor into a fabric as shown in Fig. 3 (b). This data can be analyzed using MATLAB mobile to check the efficacy of Yoga and reflexology practices.

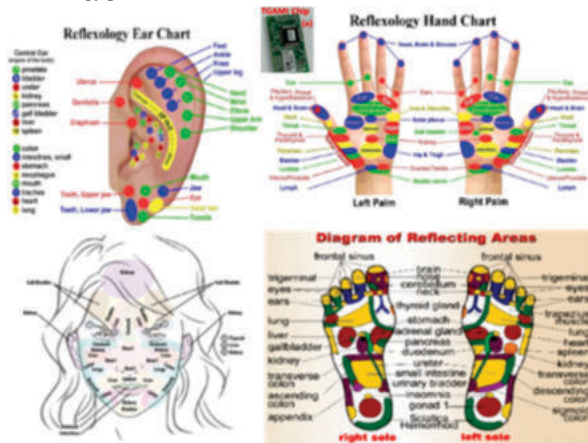


Fig. 4 Reflexology of foot, hand, ear and face.

IX. Exercise, Yoga, Reflexology and Diet

The efficacy of (a) exercise, (b) Yoga and (c) hand, foot and face (Fig. 4) reflexology [37], self-massages and new innovative diet [23] can be studied by smartphone apps related to these three areas. Exercise increases energy and oxygen levels. All three reduce stress levels by enhancing the PFC functionality. Examples of reflexology apps include reflexology charts, reflexology tutorials, reflexology secrets, etc. Examples mentioned are only related to reflexology. Some Yoga related educational apps should also be mentioned. It is a well-accepted fact that yoga and exercise are good for mental and physical health. Easy yoga that elderly can easily do and gain benefits will be designed, e.g., breathing yoga, simple pose yoga, etc. Simple and easy exercises for the elderly can be designed. Education materials, apps and videos for simple exercises and yoga can be used.

X. Healing Herbs

Informational sessions on the benefits of curcumin, black seeds, hemp seeds, coconut oil and ginkgo biloba will be conducted to explore how herbs can boost body's self-healing power to fight against a number of diseases including cancer [38]. In fact, the brain and body are optimized by the evolution to self-heal [39]. Specific benefits of the herbs are described below:

1. Curcumin: Many high-quality studies show that curcumin, the most important curcuminoid found in turmeric, has major benefits for body and brain health [40]. Although curcumin has powerful anti-inflammatory and antioxidant properties, it is found only approximately 0.3 % in turmeric [41]. Thus, an extract that contains a significant amount of curcumin is used. The problem of curcumin's poor absorption in bloodstream is solved by using piperone (found in black pepper) that increases the absorption of curcumin by 2000 % [42]. Another solution of the absorption problem is to use curcumin extract called BCM-95 that is more effective and stays longer in the system as shown in Fig. 6 [42][43]. In its anti-inflammatory role, curcumin is so powerful that it matches the effectiveness of some anti-inflammatory drugs [44]. Curcumin is a bioactive substance that fights inflammation at the molecular level [45]. In several studies, its potency has compared favorably to anti-inflammatory pharmaceutical drugs except without the side effects [46]. Curcumin is not only a potent antioxidant that can neutralize free radicals due to its chemical structure [47] but boosts the activity of the body's own antioxidant enzymes [48]. In that way, curcumin blocks the free radicals directly and then stimulates the body's own antioxidant mechanisms. Further benefits of curcumin are [49]:

- It boosts brain-derived neurotrophic factor that is linked to improved brain function and a lower risk of brain diseases.
- Curcumin leads to various improvements lowering the risk of heart disease.
- It can prevent/treat cancer.
- Curcumin may be useful in preventing and treating Alzheimer's disease.
- Arthritis patients respond very well to curcumin supplementation.

- Curcumin has incredible benefits against depression.
- Curcumin may delay aging and fight age-related chronic diseases.

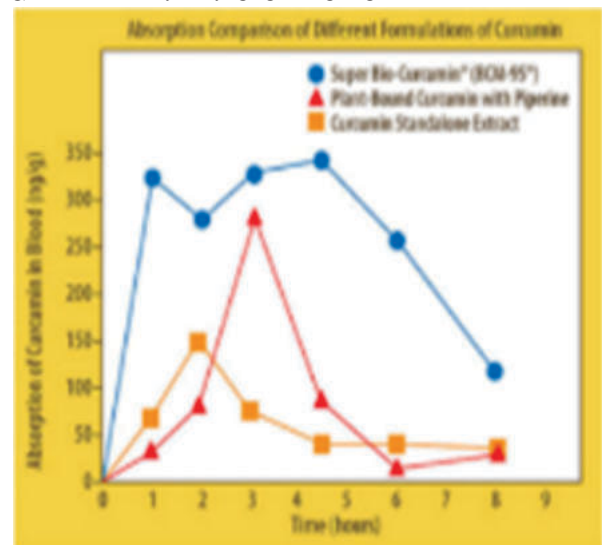


Fig. 5 Curcumin types Error! Reference

2. Black Seeds (Nigella Sativa): 630 scientific peer-reviewed articles [50] have been published about black seed oil benefits. With virtually no side effects, the healing power of black seeds is quite unbelievable [50]:

- It lowers the blood pressure and enhances testosterone level (testosterone level goes down with age) as seen in Fig. 6. Enhancing testosterone levels in elderly leads to several health benefits including desire to do things and a stronger bone structure.
- Black seeds oil contains thymol, Thymo-Quinone (TQ) and Thymo-Hydro-Quinone (THQ) that are effective against 30 human pathogens. TQ was the best antifungal compound against all of the tested dermatophytes and yeasts, followed by THQ and thymol.
- Effective against Apathy, Alzheimer's disease, Autism, Glaucoma, Dementia, Myasthenia gravis, Neurodegenerative conditions, Postural Tachycardia Syndrome, Schizophrenia, and Parkinson's disease.
- It is used as a tuberculocide and virucides to kill tuberculosis (TB) and various viruses.
- Used in medical and as general-purpose disinfectant, rapidly degrading, non-persisting pesticide.
- Used in food flavorings, perfumes, mouthwashes, and even cosmetics.

3. Hemp Seeds (Cannabis Sativa): They are rich in healthy fats and essential fatty acids [51][52]. It is a highly nutritious food and contains antioxidants, protein, carotene, phytosterols, phospholipids, as well as a number of minerals including calcium, magnesium, sulfur, potassium, iron, zinc, and phosphorus. It contains all twenty known amino acids, including the nine essential amino acids. It also contains chlorophyll, vitamins A, B1, B2, B3, B6, C, D, and E. Its 3:1 ratio of Omega-6 to Omega-3 fatty acids promotes the heart health [53] and its nutrients in the oil may help prevent a number of degenerative diseases [54]. Studies have indicated that hemp seed oil can dramatically decrease skin dryness to alleviate itching and irritation [55]. Antioxidant and anti-inflammatory properties may protect against the aging process while soothing the skin [56]. Hemp seed oil contains essential fatty acids, including Dokos-Hexanoic-Acid (DHA), that are required for brain development. DHA is crucial to the health of the brain as well as the retina of the eye, particularly in the first year of life [57]. Hemp seed oil works as a terrific alternative to traditional omega-3 fatty acid supplements and doesn't carry the same risk of mercury ingestion [58] as in fish. The essential fatty acids in hemp seed oil have been shown to promote healthy flora in the intestines and immune function [59]. Hempseed side effects: The oil in hempseeds may show blood clotting interacting with blood thinners. Due to its high fiber content, digestive symptoms like diarrhea, constipation or gas may occur if eaten large quantities of hempseeds. It's highly unlikely, but possible, to experience THC (Tetrahydrocannabinol) side

effects from eating hempseeds. Symptoms may include hallucination or euphoria. However, if hempseeds are from a reputable source, this shouldn't be an issue.

4. Coconut Oil: It contains MCTs (medium chain triglycerides) that provide high energy levels without increasing cholesterol levels. It has a number of scientifically proven benefits [60]: Coconut oil can help brain disorders, increases weight loss, builds muscle, can help fight infections, helps lose abdominal fat, curbs appetite lowers risk of heart disease, increases metabolism, protects hair against damage, anti-dandruff, moisturizes skin, acts as sunscreen, prevents gum disease and tooth decay, helps candida/yeast infections, protects your kidney and liver, treats kidney and bladder stones, reduces inflammation and arthritis, cancer prevention and treatment, reduce seizures, improves digestion, reduce symptoms of gall bladder disease and pancreatitis, prevents osteoporosis, hormone balance, stress relief, anti-aging benefits, supports thyroid functioning, eliminates free radicals damage, helps improve type 1 diabetes.

Age	Total T (ng/dl)	Free T (pg/ml)	SHBG (ug/ml)	DHEA-S (ug/dl)	Estradiol (pg/ml)
25-34	617	123	4.0	236	37.3
35-44	668	103	4.5	221	36.5
45-54	606	90	5.0	177	38.7
55-64	562	83	5.1	118	35.1
65-74	524	69	5.5	96	36.0
75-84	471	60	5.7	44	37.9
85-100	376	54	7.4	44	37.1

Fig. 6 Age-dependent testosterone levels: <https://www.menshormonalhealth.com/normal-testosterone-levels.html>

5. Ginkgo Biloba: It has been the subject of 300 hundred research papers by German researchers and is a prescription drug in Germany. It is used for the treatment of numerous conditions but available evidence supports ginkgo for managing dementia, anxiety, schizophrenia, and cerebral insufficiency (insufficient blood flow to brain) [61][62][63][64].

6. L-Theanine: It is used to replace prescription medicine such as Xanax.

Bottom Line for Herbs: Most people, especially elderly, may not like to use most of the 6 herbs described above. However, if they use some of those herbs and see the benefits they will be motivated to use all of them. Therefore, the goal is not to suggest all 6 herbs to all but rather provide a choice by informing them as suggested above. It may be pointed out that the author of this paper has used all these herbs with tremendous mind and body health benefits mentioned above [65].

XI. CONCLUSIONS

Fabric- and tattoo-bedded systems can be used (a) for body and brain health and (b) in a smart-home for controlling smart home devices [1]. Current healthcare approaches, for most ailments, seem to focus on treating the symptoms rather than the root cause of many diseases leading to a worldwide rise in health problems related to the brain, mind and MGBA (Microbiome-Gut-Brain-Axis). Further health problems can result due to side effects of prolonged use of prescription drugs.

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