Mental Optometry: The Mind's Eye, You Go Where You're Looking

Timothy H. Barclay, Scott Richards, Caleb Suddreth, Joseph Strasshofer, Lauren Shier, Alex Smyth and Danielle Novak

***Abstract*—The term, *Mental Optometry*, is newly developed concept that can be used to describe the interplay between mind, brain, and sensory interpretations. Taken from the premise of behavioral optometry and research explaining body orientation to physical field of vision, what we see or perceive with our mind's eye, emotions and behaviors will also follow in the same manner. While not explicitly referred to in such a manner, cognitive, cognitive behavioral, and cognitive bias formation theories imply such a concept as being foundational to their systems. Mental Optometry arms the theorist and practitioner with a neurobiological empowered understanding of mood, emotion, thought, and interpretations of visual stimuli such that therapeutic interventions can be developed to assist patients in recognizing and altering skewed interpretations of what they think they see (the mind's eye) – imagery that may deleteriously support negative cognitions leading to negative mood states.**

Keywords—mind's eye; perception; cognitive bias

I. A NEW THERORETICAL APPROACH: MENTAL OPTOMETRY

Mental optometry is a new term that describes the neurobiology and subsequent emotions and behaviors that result from what the mind's eye perceives. This process works in the same basic manner in which we orient our body to our physical field of vision. What we see or perceive with our mind's eye, our emotions and behaviors will also follow in the same manner as orientating the body to the physical visual field. The term, *Mental Optometry*, is in reference to the interplay between mind, brain, and sensory interpretations. The conceptualization of this new concept can be helpful in understanding and describing how the mind, brain, and body interact toward healthy (functional) and unhealthy (dysfunctional) behaviors and attitudes. As adjustments to the physical visual field can be made to keep the body orientated in the direction one intends to go, the same can be said to perception. There is precedent for the use of the term Mental Optometry and the integrated nature of vision, cognition and emotion by optometric scientists and clinicians. Behavioral optometrists have long recognized the interplay between direct visual processes, movement, positioning, targeting spatial relations, and object identification and relation, labeling and categorization via the cognitive processes related to language, interpretation, information processing, and emotion [1,2]. Behavioral optometry also acknowledges the presence and importance of plasticity within and for those processes [1].

Research on physical vision and body orientation show us that we have a neurological habit of orientating our body to our field of vision. Once information passes thorugh the visual cortex (occipitol lobe) this information is forwarded to the parietal regions and cerrubellum to regualte hand, body, and eye corrdination. Simultaneously, this information is routed to the pre-frontal cortex and limbic system where emotions and memories are added, leading to subsequent interpretations and behaviors. When we envision events with our mind's eye (i.e., imagery), many of the same neural regions of the brain are activated. Depending on how deeply we see these events play out in our mind's eye, the visual cortex and limbic system can also become activated as if we are seeing it [3,4].

Take the driving of a vehicle as a practical example. Many have experienced driving a vehicle and maintaining a lane of travel only to become distracted by something in the peripheral visual field. While keeping physical gaze to the distraction, inevitably, the vehicle will eventually drift in the direction one is looking. This is the principle at work. It is the assertion of the author's that the same process occurs with what is seen in the mind's eye. Individuals develop interpretations of visual perceptions with which they base reality. From these interpretations, internal narratives are created which can be productive and healthy or destructive and unhealthy. These narratives and interpretations dictate what we focus on; what we see with our mind's eye creates an attitudinal approach to life. As a result, and as in the initial example, one can become distracted by these faulty perceptions and end up going in an interpretative emotional direction that is not intended. The purpose of this paper is to examine the literature on visual perception and imaging, field of vision, self-talk, and the mind in an effort to gain a better understanding of the neurobiological similarities and interplay between these areas. Such information can be useful in understanding this new construct and how and why cognitive-behavioral interventions work. Understanding this process under this construct may develop further research on specific interventions used to adjust the mental field of vision that creates proactive emotional and behavioral outcomes.

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II. THE INFLUENCE OF VISION ON LOCOMOTION AND BODY ORIENTATION

Throughout the decades, there has been extensive research on the process of vision and its effects on body movement. Because the outcomes of this research are well accepted, this paper will not go into detail of those experiments other than to provide a foundation. Most of the research in this area has focused on body and head movement that informed direction of vision [5, 6, 7] while others monitored eye gaze during movement [8, 9, 10, 11]. Via a wide variety of research assessing the interplay between environment, body movement, and vision, researchers have provided evidence that visual information and fixation causes the head to reorient itself which shifts the body into alignment with the visual field in order to properly arrive at the desired object or location [12]; that vision could help control postural sway by causing the eyes to rotate in the direction of the visual stimulus in order to stabilize the body with respect to the environment [13] that vision plays a role in maintaining posture in a virtual environment, but that it has an even greater stabilizing affect in a real environment [14].

Research on the neural components involved in vision and body orientation has shown significant activation in the frontal cortex, parietal cortex, and the cerebellum [15] in addition to the parietal and temporal lobes that appear to be important in the proper control of locomotion [16]. It would be expected for the frontal cortex to be activated as it is involved in planning complex cognitive behavior and activating other networks within the brain. The parietal cortex is responsible for sensory information which includes spatial sense and navigation. This may be important in understanding how the visual field motion is used to guide locomotion. The activation of the cerebellum is expected because of how it coordinates body movements such as balance and posture by receiving information from other parts of the central nervous system. This research not only supports the notion that vision plays a role in postural control, but it also helps indicate which areas of the brain are responsible for the actions that occur.

The body does not orient itself within a vacuum; there are several processes which must first occur which will then allow the brain to form a sense of spatial awareness and subsequent body orientation, including sensory input from neurons in the neck muscles to orient the head [17]. The interaction between visual and physical information allows the prefrontal cortex to effectively orient the head and eyes, which then allows for better visual input, which allows the head and body to orient. Therefore, it is a mutual interaction between the head orientation and the visual input. Once information is processed in the visual and spatial systems, it is then processed in other regions for planning of actions; such as in the dorsolateral prefrontal cortex (DPC) [18].

Body orientation also includes where it intends to go in a trajectory. Researchers have found that the hippocampus is largely responsible for representing such trajectories, becoming active when spatial processing, planning, and goal directed decisions are involved [19] and interacting with the entorhinal cortex to determine body location and projected trajectory [20]. While the visual and spatial systems are all involved in orienting the body through space, the inferior parietal lobule (IPL) appears to function as a relay station where visual signals from the superior colliculus (SC), spatial orientation signals from the hippocampus, and motor signals from the cerebellum all come together [21]. Additionally, while the eyes allow for the intake of visual stimuli, rapid, ballistic eye movements that change fixation points (i.e., saccades), engage in looking where the individual intends to go [22]. While walking in a straight path the eyes, head, and body are all aligned; however, when an individual must turn or change directions, the eyes move in the intended direction first which results in the head turning, and finally the body will follow suit [22]. This implies and supports that the frontal eye fields and SC are responsible for planning actions such as controlling locomotion.

III. THE MIND'S EYE

The phenomenology of mental imagery, what we see with the mind's eye, has been noted as early as the Greek philosophers [3]. However, during the years of behaviorism, the concept of the mind was relegated to the basement of scientific study because the mind was something that could not be objectively measured and has only recently emerged as a legitimate cognitive process [23]. Mental images take a form of the actual image. The image that is developed though the mind is created on what is perceived by the one experiencing it. This process is believed to happen as a result of a combination of processes that include self-awareness. Morin [24] relates that awareness of self can occur at various levels to include social environment; which is a culmination of personal interactions and the messages that are perceived based on these interactions; physical stimuli; and the self which creates the cognitive process of internal narratives and images based on part or in combination of social, physical, and self.

Self-talk has been shown to be pivotal in self-regulation [25, 26, 27] problem solving [28, 29] and planning [24]. It has long been understood that maladaptive self-talk is foundational to psychopathology to include anxiety [26] and depression [30]. Internal dialogue is driven by narratives that are created based on experiences in life and become filters of what the mind's eye is focused on [31]. Morin [24, 32] proposes that although society is important in guiding an individual's self-awareness, it is ultimately the individual that directs it. What society tells an individual is normally how the individual will perceive themselves, yet one is not obliged to succumb to that perception.

One behavioral implication of self-talk is self-control. Researchers inferred that the inner voice is useful in resisting undesirable impulses and therefore, is imperative in controlling actions. They also posited that an individual's self-control is weakened when there are distractions to the inner voice [33, 34]. Research makes the connection between self-talk and self-esteem where statements made by significant others incur both positive and negative effects to a child's self-talk. The results show that positive self-talk mediates the positive statements from parents and teachers. Similarly, negative self-talk mediates the negative statements from parents and teachers, and thus on self-esteem [35, 36]. This process begins to set in place how and what an individual sees with the mind's eye.

The experience of perception and positive self-talk lends itself to the experiencing of positive emotions. It has long been recognized that experiencing positive emotions as opposed to negative emotions increases ones potential for better physical and emotional health [37, 38, 39, 40, 41, 42]. Frederickson's [39, 43] broaden-and-build theory of positive emotions which include joy, interest, contentment, pride, and love can be linked with increased levels of creativity, openness to new experiences, and sharing positive experiences with others and promote resilience. Negative emotions appear to limit the capability to engage in a positive thought-behavior repertoire and increase the propensity to activate a negative repertoire of behaviors. Positive emotions broaden the capability to engage in proactive thoughts and behaviors that promote and enhance overall well-being [40, 39]. The experiencing of positive emotions has been shown to act as a buffer against depression and that those who experience more positive emotions opposed to negative emotions appear to be more resilient [43]. This does not mean that people who use positive emotions to overcome negative experiences are not fully affected by negative emotions; they too still experience the sadness and anxiety that accompanies traumatic experiences, such as the terrorist attacks on September 11th. The difference was that they used their positive emotions to counteract the overwhelming negative emotions. This strategy of making an intentional decision to look in a particular direction with the mind's eye can also help individuals discover new strategies and knowledge to help them better cope with future crises they may face. This would appear to be the case as it follows the simple law of physics that two things cannot occupy the same space at the same time. While one's state of mind is occupied with a preponderance of negative emotions, it cannot simultaneously experience positive flow of emotions, well-being, and physical health. The concept of mental optometry posits that this process is a matter of the individual making the intentional choice to look in that direction.

Despite the mind not being easy to describe or locate within the brain, it has generally become accepted that the prefrontal cortex is mostly responsible for consciousness and conscious actions [44]. Research has shed light on the importance of the medial frontal cortex (MFC) in cognitive control, intention, choice, and volition, which are all considered to be aspects of consciousness [45, 46, 47, 48]. Changing behavior, thoughts, giving in to emotions, are an intentional acts which are hallmarks of human will. These qualities are crucial to the concept of the mind and understanding how it functions. Scientists have been attempting to uncover where volition lies within the brain; although some assume that volition and human will may not be so simple to locate due to the potential of them existing in various regions of the brain rather than just one area [49]. Volition is not without its critics. During the rise of behaviorism, volition was viewed as practically nonexistent due to the fact that inner subjective experiences of will were not capable of being empirically measured. However, modern brain scanning has enabled us to measure brain activity which theoretically allows for observable measurement of the inner workings of the mind [50].Voluntary action differs from automatic or conditioned actions in that it depends on a conscious intention to engage in or inhibit an action Such a will comes from within an individual rather than from an external stimulus. Therefore, the belief of volition as an illusion has been largely disregarded by most modern psychologists [51].

However, with the reemergence of interest in human volition comes a new challenge: where is it located? As previously believed, modern research is showing that it lies largely within the prefrontal cortex [51]. The same region has also been found to play an important role in will and self-control [52, 53]. The Lateral Prefrontal Cortex (LPC) has been found to be especially influential in the function of the mind. Similar to the rest of the prefrontal cortex, the LPC is involved in the role of regulating internal behavior [54]. Specifically, the LPC processes emotions and cognitions and plays a crucial role in integrating the frontal lobe to the amygdala [55]. This evidence that the prefrontal cortex has control over emotions supports the previously mentioned research suggesting that the prefrontal cortex has a wide reaching effect within the brain. What were once believed to have been automatic and unconscious processes are now being found capable of being influenced by conscious, intentional, and willful processes emanating from the prefrontal cortex. We see examples of this in the cognitive bias modification (CBM) research. CBM is based on the premise that individuals have a tendency for bias perceptions as previously explained. These biases function in a manner in that we are drawn to see aspects within a given environment consistent with one's state of mind whether depressive or anxious [56].

Focusing on research involving mindfulness meditation and neuroanatomic findings, Edwards, Peres, Monti, and Newberg [57] presented a summary of research on the neurobiological underpinnings of our perceptual and imaged representations of the world, specifically the relationship between mental states, emotional and cognitive processes and neurobiological/neurophysiological correlates. As noted by Edwards [57] research utilizing neuroimaging has explored correlates between meditation and neurophysiology. This supports past neurobiological research indicating an overlap between what we see with our eyes (visual perception) and what we image in our minds (visual imagery).

The thalamus plays a distinct role in sensory processing, guiding the dissemination of sensory information, interacting with the lateral geniculate, which receives raw data from the optic tract that is subsequently sent to the striate cortex for processing, and the lateral posterior nuclei which plays a role in determining spatial orientation of the body [57]. Ganis et al. [3] examined regional cerebral blood flow patterns and neuroactivation when participants were practicing visual mental imagery and, separately, perception (i.e., matching a term to a presented object), discovering that there was a 2/3 overlap between regions whether the task involved visual perception or visual imagery and suggesting a strong interconnection between visual imagery (e.g., forming a mental image) and visual perception (e.g., identifying an object as presented in a picture) – each influencing the other. The extensive overlap was maximal in frontal and parietal cortices, including numerous prefrontal regions and multiple parietal regions, including the superior parietal lobule and the precuneus – both noted to be integral to attentional process and spatial working memory, left angular gyrus, supramarginal gyrus and the inferior parietal lobule – involved in visuospatial processing.

Ganis et al. [3] also discovered that activation was evidenced in the parahippocampal gyrus, part of the limbic system, signaling activation in the vental stream during both visual imagery and visual perception tasks, perhaps related to the encoding and storing of memories of visual object and events. The take home message is that visual imagery and visual perception are interrelated, involving similar neuroanatomical areas, particularly the frontal and parietal regions but also the parahippocampal gyrus. Similar data was reported in earlier research [58]. The interconnectedness between what we actually see and what we imagine we see has been supported by past research involving neuroimaging. Specifically, visual imagery selectively influences visual perception through a complicated process, involving multiple cortical and subcortical regions, retrieving data that has been encoded in long-term memory storage and leading to the distinct impression of one's 'seeing with the mind's eye' phenomenon [3].

Researchers of visual perception have long known that what we see is the result of a sensory input signal traveling into the brain and subsequently undergoing complex neural computation resulting in the brain constructing the viewed image. That is, our interpretive mind's eye interprets and forms images of what is perceived via direct visual stimuli [59]. Research has supported the cognitive importance of imagery in that our expectations can drive our interpretation of visual stimuli [59]. In other words, we often see what we expect to see rather than what is actually present in our field of vision. This can help explain the underlying processes behind "In the eye of the beholder" sentiments, and the psychology and neurophysiology underlying visual perception and categorization [60].

Visual imagery selectively influences visual perception through a complicated process, involving multiple cortical and subcortical regions, retrieving data that has been encoded in long-term memory storage and leading to the distinct impression of one's 'seeing with the mind's eye' phenomenon [3]. Utilizing positron emission tomography and functional magnetic resonance imaging, Ganis et al. [3] explored the interrelatedness between imagery and perception. Specifically, a 2/3 overlap between different brain regions occurs whether a task involved visual perception or visual imagery and suggesting a strong interconnection between forming a mental image (i.e., imagery) and identifying an actual object as presented in the visual field (i.e., perception) – each influencing the other. The extensive overlap was maximal in frontal and parietal cortices and, of particular interest, brain regions activated in participants practicing visual imagery were a subset of those regions activated in participants practicing visual perception. Additionally, numerous prefrontal regions and multiple parietal regions, including the superior parietal lobule and the precuneus – both noted to be integral to attentional process and spatial working memory, left angular gyrus, supramarginal gyrus and the inferior parietal lobule – involved in visuospatial processing; and activation was also evidenced in the parahippocampal gyrus, part of the limbic system, signaling activation in the vental stream during both visual imagery and visual perception tasks, perhaps related to the encoding and storing of memories of visual object and events. The result is that visual imagery and visual perception are interrelated, involving similar neuroanatomical areas, particularly the frontal and parietal regions but also the parahippocampal gyrus. Similar data was reported in earlier research [58].

Research has also supported the significant role that affective states play in imagery, visual perception, and sensory processes. A variety of neurophysiological and neuropsychological mechanisms lie at the root of visual perception and imagery indicating that what we see is significantly influenced by our affective states. Researchers have discovered disturbances of visual motion perception in patients with psychiatric illness, including depression [61], schizophrenia [62, 63]; and bipolar disorder [64]; and some disturbances were more pronounced in patients suffering a depressed state [65].

Working on the well supported hypothesis that conscious perception involves a comparison between bottom-up and top-down information processing in the cerebral cortex, [66] supports that the conscious perception of sensory stimuli is strongly influenced by mood states. Negative mood promotes a bottom-up processing style focusing on incoming information but limiting the amount of interpretation based on activated concepts previously stored and retrieved to assist in interpreting the present sensory stimulus and positive mood promoted top-down processing [67, 66, 68]. Presumably, such a pattern would disallow or limit interpreting present sensory stimuli based on information stored from past experience – information such as patterns of successes or positive outcomes that would help the individual place a more positive spin on currently received sensory stimuli. Indeed, past research has supported that individuals in sad moods are more likely to interpret sensory information without reliance on heuristics (i.e., store information related to past events) and with a local focus (i.e. seeing the trees rather than the forest) rather than a global focus [69, 70, 71]. Furthering the research supporting an interconnection between visual stimuli processing and mood, Hills and Lewis [72] found that mood was directly related to distinct facial processing styles; specifically, happy-induced individuals focused on others' eyes whereas sad-induced individuals directed their attention away from the eyes of others. As noted, research supports an interconnection between mood, judgment, visual processing, and interpretation of visual and other sensory information (for a comprehensive summary of research on the neurobiological underpinnings of our perceptual representations of the world, see Edwards et a., [57].

Additionally, visual processing deficits, consistent with a disturbance in the information signaling traveling from the thalamus to levels of cortical processing, are sensitive to mood states and psychiatric disease [64]. Research utilizing functional magnetic resonance imaging (fMRI) also supports that early stages of sensory visual processing are influenced by affective states and are likely to influence subsequent visual stimulus interpretation and perception [73]. Negative mood states, including sadness [74], fear [75], and anger [76] have a direct effect on visual perception and interpretation of visual stimuli. Specific to dysphoric individuals, the quantity and quality of visual information retrieval, processing, and interpretation is particularly sensitive to defocused information [77]. Research has also supported that gaze is also partially mood and attitude congruent, with pessimistic individuals gazing more at negative and unpleasant images than optimistic individuals [78].

IV. DISCUSSION

The practice of mental optometry as a therapeutic approach offers the potential to assist practitioners and patients to better understand the interplay between our thoughts, moods, visual imaging and optical sensory perception. The plasticity of the brain is well founded within the research. However, with functional imaging, this has been a newly discovered development, particularly in relation to psychotherapy interventions [79]. The effectiveness of any form of psychotherapy is the alleviation of symptoms. For this to take place requires changes in perception, attitude, and behavior. These outcomes do not take place without corresponding changes within the brain [31]. Alterations to cognitive schemas resulting in changes to what is attended to in one's environment are foundational to cognitive based therapies [80, 26]. Errors in cognition such as fundamental attribution bias [81] and belief perseverance [82] can explain how and why people selectively attend to aspects of their environment that conform to their state of mind or in other words, what they see with their mind's eye. These behaviors can also be said to contribute to the creation and use of defense mechanisms which serve as functional aspects of survival and homeostasis [83]. The direction we look with the mind can reinforce these mechanisms which can reinforce overall mental health or mental illness.

Similar to the causes of blurred vision [84], our interpretations of visual perceptions (i.e., what we see perceive with the mind's eye) can become distorted. And, similar to optometric treatments of myopia, in which the disturbance is rectified with either corrective lenses or surgery which change light refraction, our distorted interpretations of visual perceptions, created based on significant events, can be treated by retraining what the mind attends to. We create internal narratives based on past events that create and reinforce biases which become the lens in which we view and interpret the world, relationships, and our interaction within these paradigms. These narratives are largely driven by unconscious processes and serve as the basis for our beliefs about others and ourselves. This process determines the field of vision within the mind's eye and creates a confirmatory bias. A result of this bias is that one sees and perceives things within their environment including interpretations of circumstances and interactions with others which elicits subsequent emotions and behaviors which can often times be dysfunctional. As one learns to train the mind to look through the circumstances and create alternative narratives, the field of vision expands in the mind's eye creating more regulated emotions and behaviors.

There are a multitude of complicated and interconnected processes and brain regions involved in the interplay of affect, imagery, perception, movement, and orientation. Armed by the neuroscience underlying visual processes, including perception and imagery, Mental Optometry arms the practitioner with a neurobiological empowered understanding of mood, emotion, thoughts, and interpretations of visual stimuli such that therapeutic interventions can be developed to assist patients in recognizing and altering skewed interpretations of what they think they see (the mind's eye) – imagery that may deleteriously support negative cognitions. Such a concept also makes the complex processes of thought, emotion, and behavior easier to understand which alone can help facilitate change.

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AUTHORS' PROFILE

Dr. Timothy H. Barclay, is an Associate Professor of Psychology at Liberty University. Lynchburg, VA. and a licensed clinical psychologist.

Dr. Scott Richards, PA-C, DFAAPA is an Associate Professor and Founding Program Director of the Physician's Assistant Program in the School of Health Sciences at Emory and Henry College, Marion, VA. He is also a practicing physician's assist and clinical psychologist.

Caleb Suddreth, BS. is a psychology research assistant at Liberty University, Lynchburg, VA

Joseph Strasshofer is a psychology research assistant at Liberty University, Lynchburg, VA.

Laruen Shier is a psychology research assistant at Liberty University, Lynchburg, VA.

Alex Smyth, BS. is a psychology research assistant at Liberty University, Lynchburg, VA.

Danielle Novak is a psychology research assistant at Liberty University, Lynchburg,VA