**ORIGINAL ARTICLE**

# A Neuroanatomical Framework for Understanding Dream Content

Calvin Kai-Ching Yu[1*]

[1]Department of Counselling and Psychology, Hong Kong Shue Yan University, Hong Kong

**ABSTRACT**

The neurostructural model of dreaming avers that dreams are actively generated by the neural network formed by the mesolimbic-dopaminergic pathway, the ventromesial-orbitofrontal cortex, and the inferomesial temporal-limbic-occipital pathway as a result of the disengagement of the frontal convexity. Although the narrative content of dreams usually appears to be uncanny and unintelligible, there are typical dream themes that are similarly experienced by most people. On the other hand, some common waking-life activities that entail prefrontal executive functions rarely emerge in dreams. The cross-cultural resemblance of prevalence profiles for typical dream themes suggests that the formation of dream images is regularly biased toward a specific group of themes and is operated on by highly stable mechanisms and predispositions. In this article, I propose that the functional architecture of dreaming as depicted by the neurostructural model can provide a framework for understanding these predispositions.

**Keywords:** dopamine, dream content, dream themes, neuroanatomical correlates, typical dreams

## INTRODUCTION

The lesion method that combines clinical examination and structural imaging has a unique role in understanding the relationship between the brain and behaviors. Functional imaging, such as positron emission tomography (PET) and functional magnetic resonance imaging (fMRI), detects dynamic changes in blood flow or metabolic rate across different brain regions and different time points. Despite its apparent advantage over structural imaging, which

provides only static images of the brain, functional imaging cannot show whether a specific neuroanatomical area is indispensable in a functional network. There have been some obscure findings concerning the role of the supramarginal gyrus (BA40) in rapid-eye-movement (REM) sleep among PET studies. For instance, Maquet et al. (1996) detected an increase in cerebral blood flow over the right anterior supramarginal gyurs during REM sleep and consistently, according to Hong, Gillin, Dow, Wu, and Buchsbaum (1995), the cerebral metabolic rate of glucose in the supramarginal gyurs was correlated with the number of rapid eye movements. On the other hand, Braun et al. (1997, 1998) found reduced cerebral blood flow in the supramarginal gyrus during REM sleep. Notwithstanding the conflicting PET findings, Yu's (2006b) clinicoanatomical study demonstrates that lesions to the supramarginal gyrus and its adjacent areas, such as the sensory cortex, do not necessarily lead to cessation of dreaming. This suggests that although the activity of the supramarginal gyrus is

**\*Correspondence:** calvinkcyu@ymail.com
Calvin Kai-Ching Yu, Department of Counselling and Psychology, Hong Kong Shue Yan University, 10 Wai Tsui Crescent, Braemar Hill Road, North Point, Hong Kong.

**Sleep and Hypnosis
Submit your manuscript at
www.sleepandhypnosis.org**

associated with REM sleep, the supramarginal gyrus, wherein cross-modal, high-level perceptual-emotional information processing takes place – including empathic understanding and overcoming egocentrically biased judgments (Silani, Lamm, Ruff, & Singer, 2013) – does not serve as an integral part of the functional network of dreaming. Because each neuroimaging method has its strengths and limitations, the establishment of a neurophysiological model that accounts for a function should be founded on the comparison of findings generated by different neuroimaging methods.

## The Neurostructural Model of Dreaming

By overlaying the neuroanatomical regions identified by both lesion and PET studies, Yu (2001a, 2001b, 2003, 2006a, 2006b, 2007) developed a neurostructural model of dreaming, according to which dreams are actively generated by the neural circuitry that connects the mesolimbic-dopaminergic pathway, the ventromesial-orbitofrontal cortex, and the inferomesial temporal-limbic-occipital pathway as a consequence of the widespread deactivation over the frontal convexity. Specifically, the lateral orbitofrontal cortex is deactivated; therefore, the inhibitory projections from the prefrontal cortex to the fear-aggression center in the temporal pole and amygdala, to the instinctual-drive center in the hypothalamus, and to the reward center in the ventral striatum of the mesolimbic-dopaminergic pathway are weakened, thereby promoting instinctual and motivational ideation. Since the decision-making and executive systems in the dorsolateral prefrontal cortex are deactivated, direct motor outputs are suppressed. Thoughts and impulses can only be discharged in the form of hallucinations through the inferomesial temporal-limbic infrastructure, which bridges the subcortical motivational centers and the extrastriate visual representation system. Moreover, because of missing visual inputs from the external world as signified by the inactivity of the striate cortex, the suspension of reality testing, selective attention, and working memory resulting from the deactivation of the experience-dependent growth prefrontal cortex, and the active process of temporal regression and distortion transpiring in the temporo-occiptal region, the formation of dream

images is prone to the effect of egoistic, regressive, and projective contextualization.

The neurostructural model places much stronger emphasis on the forebrain mechanisms than does the classical brainstem theories (Jouvet, 1962; Hobson, 1988; Hobson & McCarley, 1977). It acknowledges, however, that the brainstem plays a vital part in the functional architecture of dreaming (Yu, 2005). Ponto-geniculo-occipital (PGO) waves – the distinctive indicator that precedes REM sleep – originate in the pons of the brainstem (Jouvet, 1962). According to the activation-synthesis hypothesis (Hobson, 1988; Hobson & McCarley, 1977), REM cycles are regulated by the mesopontine tegmentum, nucleus locus coeruleus, and dorsal raphe nucleus of the pons. Furthermore, although there are some controversies surrounding the mechanisms of REM-sleep atonia (Brooks & Peever, 2008a, 2008b), the motor nucleus of the trigeminal nerve is situated in the pons, lesions to which are known to cause REM without atonia (Morrison, Sanford, Ball, Mann, & Ross, 1995).

From the functional perspective, the ascending reticular activating system of the brainstem tegmentum is crucial to maintain a certain level of consciousness necessary for any mental activities, such as dreaming, and neurological insults circumscribed to the pontine tegmentum can result in coma (Parvizi & Damasio, 2003). This most basic form of awareness – the protoself, in Damasio's (1999; Parvizi & Damasio, 2001) term – arises from the neural circuit composed of the brainstem nuclei, the hypothalamus, and the insular cortex, which maps bodily signals and regulates and represents the body's internal states. It is interesting to note that Panksepp (1998a, 1998b; Panksepp, Asma, Curran, Gabriel, & Greif, 2012) also localized the primary-process consciousness to the mesencephalic structures. In particular, the affective afferents receiving from the hypothalamus and other limbic structures and the viscero-somatic information receiving from the somatosensory systems converge in the interface area of the periaqueductal gray within the tegmentum and the superior colliculi of the tectum, thus generating the intrinsic sense of self. It seems that the involvement of the midbrain in REM sleep alludes to the rudimentary role played by the affective-body self in dream formation.

The neurostructural model of dreaming, since its development, has continued to be substantiated by studies that follow. For instance, no dream recall or only infrequent, brief dream reports can be obtained from patients with striatopallidal (Leu-Semenescu et al., 2013) or temporo-occipital lesions (Bischof & Bassetti, 2004; Poza & Martí Massó, 2006), even with the aid of REM awakenings. As with the mechanisms described by Yu's neurostructural model, furthermore, the dynamic interaction between the higher-order association cortices and the unimodal sensorimotor areas observed by the fMRI method (Chow et al., 2013), the negative connectivity between the prefrontal region and occipito-temporo-cerebellar areas of the brain detected by the high-resolution EEG method (Yu, 2015a), and the loss of fronto-posterior gamma coherence during REM sleep (Corsi-Cabrera, Guevara, & del Río-Portilla, 2008) imply that dream formation and bizarreness are facilitated by the immobilization of the frontal executive functions.

## The Constancy of Dream Content

A most notable feature of the narrative content of dreams is its lack of coherence with waking cognition. Early brainstem-driven theories attribute the bizarreness of dream content to the uninvolved forebrain, which only passively and nonspecifically synthesize inchoate data generated by the autoactivated brainstem mechanisms. From this perspective, the conscious experience of dreaming is nothing more than a random epiphenomenon resulting from bewildering information processing. If dream narratives are fundamentally determined by random processes, then it is unlikely that people from different cultures with different backgrounds would share similar dream content. Contrary to this proposition, there is strong evidence that the opposite is true.

Some content analytical (Maggiolini, Cagnin, Crippa, Persico, & Rizzi, 2010; Maggiolini, Lazzaroni, & Crippa, 2012; Mathes & Schredl, 2014; Mathes, Schredl, & Göritz, 2014; Yu, 2015b) and survey studies (Gahagan, 1936; Griffith, Miyagi, & Tago, 1958; Nielsen et al., 2003; Schredl, Ciric, Götz, & Wittmann, 2004; Yu, 2008, 2009b, 2010, 2011, 2012) have been conducted in different countries to investigate the prevalence of dream themes.

They have established a cross-cultural replication of the high prevalence rates for some specific dream images. The theme of falling, for example, was experienced by more than 70% of participants in Gahagan's (1936) American sample, the American sample and the Japanese sample of Griffith et al.'s (1958), Nielsen et al.'s (2003) Canadian sample, Yu's (2008, 2009b, 2010, 2011, 2012) Chinese samples, and the German sample of Schredl et al. (2004). Besides falling, many other prevalent dream themes have been identified across cultures, such as eating delicious foods, sexual experiences, embarrassment about using a toilet, flying, being chased and pursued, and failing an examination.

In contrast to those prevalent dream themes, some themes have been found to rarely occur in dreams. The theme "someone having an abortion," for example, was dreamed by 5.4% of participant in Yu's (2012) Chinese sample, 5.1% of participants in Nielsen et al.'s (2003) Canadian sample, and 2.9% of participants in the German sample of Schredl et al. (2004). Perhaps even more strikingly, some very common cognitive activities in waking life – including reading, writing, typing, and calculating – can hardly be found in dreams (Hartmann, 2000; Maggiolini et al., 2010). Accordingly, people in different ethnic settings share not only the similar tendency to dream certain themes but also the similar tendency not to dream certain themes. It is noteworthy, furthermore, that the discrepancies between typical and atypical dream themes in their prevalence rates are substantial. In one of Yu's (2010) Chinese sample, for instance, the prevalence rates of the themes "school, teachers, studying" (95.2%) and "searching for a certain place" (91.8%) are almost 30 times more than that of theme "someone having an abortion" (3.3%). This underscores the modus operandi of dream formation, which is regularly biased toward a specific group of themes and is governed by nonrandom neurobiological mechanisms.

## The Application of the Neurostructural Model in Understanding the Narrative Content of Dreams

The functional attributes of the neural network of dreaming can perhaps provide the foundation for

understanding the predispositions that modulate the formation of dream content. According to the neurostructural model, the widespread deactivation over the frontal convexity sets off the dream mechanisms orchestrated by the mesolimbic-dopaminergic pathway, the ventromesial-orbitofrontal cortex, and the inferomesial temporal-limbic-occipital pathway. Since the prefrontal cortex is not fully operative during dreaming, activities that necessitate executive functions are rendered difficult in dreams. Therefore, although the episodes of learning, school, and work-related activities frequently dominate both dreaming and waking life, the dreamer hardly ever carries out mental calculations, reads a book word by word, writes sentences, or works on a computer from the first-person perspective. Moreover, the loosening of executive control over the limbic system and the suspension of reality testing foster the milieu conducive to egoistic and delusional thoughts.

Dopaminergic systems play a central role in the neurostructural model (Yu, 2001b, 2007). This alludes to the analogous neurophysiological mechanisms of dreaming and psychosis in that dopaminergic supersensitivity has hitherto been deemed to be the major neural correlate of psychotic symptoms. In addition, chemically modulating the mesolimbic-dopaminergic system can induce grandiosity (Krystal et al, 2005; Vollenweider, Vontobel, Øye, Hell, & Leenders, 2000), whereas the temporal lobe is evidently implicated in psychotic suspiciousness and persecution (Blackwood, Howard, Bentall, & Murray, 2001; Blackwood et al., 2000; Geroldi et al., 2000; Geroldi, Bresciani, Zanetti, & Frisoni, 2002; Tost et al., 2010; Whalley et al., 2007).

Yu's (2009a, 2009b, 2010, 2012) studies on dream themes demonstrated that both classic bizarre themes pertaining to schizophrenia and psychotic disorders, including grandiose (e.g., "having magical powers"), persecutory (e.g., "some people plotting against you"), religious (e.g., "becoming a certain form of devil"), erotomanic (e.g., "having a sexual relationship with a powerful person or celebrity"), jealousy (e.g., "spouse or lover having extramarital relations or being unfaithful"), and somatic delusions (e.g., "something seriously wrong with your body"), and less bizarre themes of the paranoid

suspiciousness that denotes paranoid personality disorder (e.g., "people wanting to take advantage of you") are common in dreams. The dream theme "having magical powers," for instance, was reported by 64.5% of participants in Yu's (2012) sample.

Replicated statistical findings suggest that a considerable number of prevalent dream themes can be classified into three categories: Grandiosity, Persecution, and Ego Ideal (Yu, 2009a, 2009b, 2010, 2012). Dream themes subsumed under the first category, such as "having a superior status," "having magical powers," and "becoming a powerful person or celebrity," are prototypes of a grandiose delusion. Dream themes placed in the second category, such as "being chased or pursued," "being physically attacked," and "some people plotting against you," can be compared to those of persecutory delusions. The Ego Ideal category does not directly involve classic psychotic delusions but is concerned with issues surrounding dreamers' falling short of social expectations and paranoid suspiciousness, such as "failing an examination," "arriving too late," and "blaming others for blaming you wrongly."

The Grandiosity, Persecution, and Ego Ideal categories, which represent three major predispositions that modulate dream content, can be to some extent accounted for by the functional attributes of the three major constituents that comprise the neurostructural network of dreaming. In light of the neurobiological isomorphism between dreaming and psychosis, dreaming of grandiose and persecutory themes can be readily ascribed to the robust activation of the mesolimbic-dopaminergic system and the inferomesial temporal-limbic pathway. The ventromesial-orbitofrontal cortex controls primitive inhibition that is not necessarily maintained by logical scaffolding. Rather, such moral behavior is modulated through stimulus-response learning and social affective interactions, for example, gaining acceptance from significant others (Yu, 2003, 2006a, 2009b). This function is germane to an image of the ideal self, toward which the ego aspires. Accordingly, dream images involving arriving too late, failing an examination, being blamed or punished, or the feeling of embarrassment might reflect the functional characteristics of the active ventromesial-orbitofrontal cortex.

In addition to the three major dream predispositions, Yu (2009b, 2010, 2012) identified 12 other dream predispositions (see Table 1), which can also be mapped onto the neurostructural model (see Table 2). The Appetite-Instinct predisposition – as exemplified by those themes such as "eating delicious foods," "finding

| Table 1: 15 Dream Predispositions | | |
|---|---|---|
| **Dream predispositions** | **Description** | **Examples of dream themes** |
| Grandiosity | Classic grandiose themes that can be observed in schizophrenia | - Having superior knowledge or mental ability<br>- Having magical powers |
| Persecution | Classic persecutory themes that can be observed in schizophrenia | - Some people plotting against you<br>- Being killed |
| Ego ideal | Themes involving primitive moral functions and their affective effects, e.g., shame and guilt. | - Failing or performing very badly in front of others (e.g., teachers, classmates, bosses, colleagues, etc.)<br>- Being blamed or punished |
| Delusion | Themes selected from the Grandiosity, Persecution, and Ego Ideal categories | - Becoming a certain form of deity<br>- Encountering a devil in some form |
| Paranoia | Themes signifying paranoid personality disorder and schizotypal personality disorder | - Others not giving you proper credit for your achievements<br>- Blaming others for blaming you wrongly |
| Erotomania | Themes relating to delusional disorder of the erotomanic type | - Having a love affair with a powerful person or celebrity<br>- Having a sexual relationship with a powerful person or celebrity |
| Appetite-instinct | Basic desires or foraging, consummatory activities; a key component of the Grandiosity predisposition | - Encountering the person that you like or you want to see<br>- Finding money, winning a lottery, or becoming rich |
| Sensorimotor excitement | Themes featuring vigorous sensory or motor activities | - Flying, soaring, or floating through the air<br>- Being chased or pursued, but not physically injured |
| Sex | Situations or activities relating to sex | - Being nude<br>- Being inappropriately dressed |
| Fighting | Aggressive activities, weapons, and tools that have been used as symbols | - Knives, swords, or daggers<br>- Killing someone |
| Animal symbolism | Animals that have long been used as symbols | - Dragons, tortoises, or snakes<br>- Ferocious beasts |
| Unusual creature | Nonhuman living beings often described by people with psychotic or dissociative episodes | - Creatures with both human and animal characteristics<br>- Seeing extra-terrestrials |
| Object-relation | Issues surrounding separation and reunion, previous, regressive relationships; a key component of the Ego Ideal predisposition | - Reuniting with a long-lost fellow or childhood playmate<br>- A person now alive as dead |
| Convenient dreaming | Classic themes that fend off sleep-disturbing stimuli by contextualizing or satisfying them in dreams | - Eating delicious foods<br>- Being unable to find, or embarrassed about using, a toilet |
| Inhibition | Themes featuring either the physical inhibition of body movements or the psychological prohibition of certain behaviors | - Being tied, unable to move<br>- Feeling dog-tired, lack of strength in the whole body, and very difficult to move — but you have not stopped, and keep walking very hard |

| Table 2: Neuroanatomical Correlates of Dream Predispositions | | | |
|---|---|---|---|
| **Neuroanatomical Correlates of Dreaming** | **Functional Characteristics Relating to Dreaming** | **Functional Implications for Dreaming** | **Associated Dream Predispositions** |
| Deactivation of the prefrontal convexity, including the dorsolateral prefrontal cortex and the lateral orbitofrontal cortex | Experience-dependent maturation; reality testing; rational, adultlike thoughts; moderating behavior to maximize returns; delaying gratifications; complying with social norms; high-level inhibition substantiated by moral, objective, and logical reasoning; decision making; motor discharge | Developmental regression; loss of reality testing; irrational, childish thoughts; egocentricity; egoistic perspective; subjective elaboration of stimuli; self-referential projection; impulsive tendency; immediate gratifications; suppression of motor discharge | Delusion; Paranoia; Inhibition (physical) |
| Activation of the brainstem including the pons, various midbrain structures, and the vestibular system | Basic form of consciousness; mapping bodily signals; relaying sensory inputs; representing and regulating internal body states; body balance; proprioception | Protoself; primary-process consciousness; viscera-somatic, vestibulo-proprioceptive experiences; REM-atonia | Sensorimotor excitement; Convenient dreaming; Inhibition (physical) |
| Activation of the ventromesial-orbitofrontal cortex | Experience-dependent growth; being influenced by parenting and social conditioning throughout maturation; primitive inhibition not necessarily maintained by moral and logical reasoning but learned via social and affective interactions and stimulus-response learning; reward-based stimulus-reinforcement association learning; subjective pleasantness and unpleasantness; monitoring gain and loss | The sense of the self built upon expectation and achievement; experiences of social reinforcement and punishment | Ego ideal; Paranoia; Object-relation; Inhibition (psychological) |
| Activation of the mesolimbic-dopaminergic pathway, including the striatum, caudate nucleus, and hypothalamus | Grandiose delusion; instinctual, exploratory, and consummatory behaviors | Grandiose delusion; instinctual impulses; pleasure-driven activities; seeking gratification of needs; sexual desire | Grandiosity; Erotomania; Appetite-instinct; Sex |
| Activation of the inferomesial temporal-limbic-occipital pathway, including the temporo-occipital junction, amygdala, and hippocampal and parahippocampal areas | Persecutory delusion; fear and anger; episodic memory; connecting the limbic system and the visual representation system; converting thoughts into images; object and symbolic representation; fear conditioning and associative learning; complex visual perception and hallucination | Persecutory delusion; frightening and violent themes; temporal regression and retrieval of old memories; symbol formation; metaphoric expression; perceptual distortion | Persecution; Fighting; Object-relation; Unusual creature; Animal symbolism |

money, winning a lottery, or becoming rich," "searching for something," and "encountering the person that you like or you want to see"– is thought to match with the mesolimbic-dopaminergic pathway, especially the nucleus accumbens and the anterior caudate nucleus of the striatum. This resonates with the neuroscientific evidence that the mesolimbic-dopaminergic pathway, damage to

which can cause dream cessation in tandem with adynamia (Solms, 1995, 1997; Yu, 2001b, 2007), governs appetitive-instinctual, foraging behaviors (Panksepp, 1998a) and romantic love (Aron et al., 2005). Likewise, the hypothalamus and in particular the preoptic area, which has the most robust increase in cerebral blood flow within the dopaminergic systems during REM sleep (Braun et al.,

1997), is centrally involved in male sexuality (Panksepp, 1998a). This perhaps explains why sexual and erotomanic themes are common in men's dreams.

As pointed out in the outline of the neurostructural model, the mesencephalic structures, together with the hypothalamus and the insula, constitute the neural circuit in which affective and viscero-somatic afferents amalgamate to produce the most rudimentary form of consciousness. Indeed, bodily experiences are often featured as some prominent themes in dreams, such as soaring or floating through the air, teeth falling out, being tied and unable to move, searching for a toilet to empty the full bladder, and craving for or indulging with tasty foods. The Sensorimotor Excitement, Inhibition, and Convenient Dreaming categories signify these inclinations to fabricate dream images by contextualizing bodily stimuli. Accordingly, dreams of flying, falling, and being chased, which are characterized by bodily balance and movements, might be related to the excitation of the vestibular system located in the caudal pons. In a similar vein, having difficulty walking and being frozen with fright in dreams are likely to be derived from the projective contextualization of REM atonia and the feeling of heaviness and tiredness in the body.

Since the function of abstract thinking executed by the prefrontal cortex is compromised, dream thoughts, particularly intangible ones, preferentially find concrete expression via visualization. The activity over the temporo-occipital junction is robust during REM sleep and injury to this specific area renders dream activities almost impossible (Yu, 2001a, 2006b). The mesial temporal lobe is important for learning arbitrary associations between pairs of abstract designs, words, or symbols (Achim, Bertrand, Montoya, Malla, & Lepage, 2007; Jonin et al., 2013; Law et al., 2005; Ojemann & Schoenfeld-McNeill, 1998; Smith, Bigel, & Miller, 2011) – namely, paired-associate learning and the basic building block for symbolization. Furthermore, the inferotemporal cortex is known to bridge the visual cortex and the limbic system with its intense afferent and efferent connections with both regions, such as the hypothalamus, amygdala, entorhinal area, and fusiform gyrus (Akert, Gruesen, Woolsey, Meyer, 1961; Creutzfeldt, 1995; Prelevic,

Burnham, & Gloor, 1976; Turner, Mishkin, & Knapp, 1980; Whitlok & Nauta, 1956).

Lesions to the fusiform gyrus have long been considered the neuroanatomical correlates of prosopagnosia (Barton, Press, Keenan, & O'Connor, 2002; Delvenne, Seron, Coyette, & Rossion, 2004; Rossion et al., 2003; Schiltz et al., 2006; Steeves et al., 2009) and object agnosia (Capitani et al., 2009; Karnath, Rüter, Mandler, & Himmelbach, 2009; Konen, Behrmann, Nishimura, & Kastner, 2011; McCarthy & Warrington, 1986). Similarly, it has been well established that the amygdala and the entorhinal cortex are the neural substrates for fear and aggression and memory formation and consolidation. Panksepp (1998a) localized both the fear and rage systems to the neural pathway running from the amygdala, via the medial hypothalamus, down to the mesencephalic periaqueductal gray, although within the amygdala, the two systems can be clearly differentiated, with the fear system being more lateral and the rage system being more medial. Evidence repeatedly shows that the amygdala contributes to the acquisition of Pavlovian fear conditioning and the modulation of memory consolidation of inhibitory avoidance (Daher & Mattioli, 2015; Moscarello & LeDoux, 2013; Wilensky, Schafe, & LeDoux, 2000; Zinn et al., 2009). At the moment of retrieving learned inhibitory avoidance, the entorhinal cortex seems to act as an efferent output of the amygdala and hippocampus (Izquierdo & Medina, 1993).

Penfield's (1958; Penfield & Rasmussen, 1955) seminal experiments demonstrated that electrical stimulation of the temporal lobe alone can trigger dreamlike hallucinations that are distinguished by perceptual distortion, reliving of past episodes, and ostensibly unfamiliar images fabricated by the condensation of previous experiences (see Yu's (2001a) article, for a comparison between experimentally-induced hallucinations and dream mechanisms). The similar phenomenon has also been reported in more recent studies (e.g., Gloor, 1990; Gloor, Olivier, Quesney, Andermann, & Horowitz, 1982; Vignal, Maillard, McGonigal, & Chauvel, 2007). The functions performed by all abovementioned neuroatomical structures along the inferomesial temporal-limbic-occipital pathway – including paired-associate learning, face recognition, object representation, memory retrieval, assigning affective

meaning to an object or symbol, and extracting and assembling elements of previous experiences to create a novel image – are crucial for subserving the dream work, which transforms emotionally-laden thoughts into their pictorial counterparts. The activation of the inferomesial temporal-limbic-occipital pathway therefore underscores the dream process that affective feelings, especially apprehension and aggression, are concretized, dramatized through visual hallucinations – an image of being pursued by or fighting back against a ferocious beast or alien, for instance.

## CONCLUSION

Dreams appear to be bizarre because of their delusional nature and their incongruence with waking cognition and reality. No two dreams are exactly the same but there are typical themes that most people dream. The investigation of these typical themes reveals some major predispositions for the formation of dream content, which can be more easily comprehended when the neurostructural network of dreaming is taken into account.

## References

Achim, A. M., Bertrand, M.-C., Montoya, A., Malla, A. K., & Lepage, M. (2007). Medial temporal lobe activations during associative memory encoding for arbitrary and semantically related object pairs. *Brain Research, 1161,* 46-55.

Akert, K., Gruesen, R. A., Woolsey, C. N., Meyer, D. R. (1961). Klüver-Bucy syndrome in monkeys with neocortical ablations of temporal lobe. *Brain: A Journal of Neurology, 84,* 480-498.

Aron, A., Fisher, H., Mashek, D. J., Strong, G., Li, H., & Brown, L. L. (2005). Reward, motivation, and emotion systems associated with early-stage intense romantic love. *Journal of Neurophysiology, 94,* 327-337.

Barton, J. J. S., Press, D. Z., Keenan, J. P., & O'Connor, M. (2002). Lesions of the fusiform face area impair perception of facial configuration in prosopagnosia. *Neurology, 58,* 71-78.

Blackwood, N. J., Howard, R. J., Bentall, R. P., & Murray, R. M. (2001). Cognitive neuropsychiatric models of persecutory delusions. *The American Journal of Psychiatry, 158,* 527-539.

Blackwood, N. J., Howard, R. J., ffytche, D. H., Simmons, A., Bentall, R. P., & Murray, R. M. (2000). Imaging attentional and attributional bias: An fMRI approach to the paranoid delusion. *Psychological Medicine, 30,* 873-883.

Bischof, M., & Bassetti, C. L. (2004). Total dream loss: A distinct neuropsychological dysfunction after bilateral PCA stroke. *Annals of Neurology, 56,* 583-586.

Braun, A. R., Balkin, T. J., Wesensten, N. J., Carson, R. E., Varga, M., Baldwin, P., Selbie, S., Belenky, G., & Herscovitch, P. (1997). Regional cerebral blood flow throughout the sleep-wake cycle. An H2(15)O PET study. *Brain: A Journal of Neurology, 120,* 1173-1197.

Braun, A. R., Balkin, T. J., Wesensten, N. J., Gwadry, F., Carson, R. E., Varga, M., Baldwin, P., Belenky, G., & Herscovitch, P. (1998). Dissociated pattern of activity in visual cortices and their projection during human rapid eye movement sleep. *Science, 279,* 91-95.

Brooks, P. L., & Peever, J. H. (2008a). Glycinergic and GABA(A)-mediated inhibition of somatic motoneurons does not mediate rapid eye movement sleep motor atonia. *Journal of Neuroscience, 28,* 3535–3545.

Brooks, P. L., & Peever, J. H. (2008b). Unraveling the mechanisms of REM sleep atonia. *Sleep, 31,* 1492–1497.

Chow, H. M., Horovitz, S. G., Carr, W. S., Picchioni, D., Coddington, N., Fukunaga, M., Xu, Y., Balkin, T. J., Duyn, J. H., & Braun, A. R. (2013). Rhythmic alternating patterns of brain activity distinguish rapid eye movement sleep from other states of consciousness. *PNAS Proceedings of the National Academy of Sciences of the United States of America, 110,* 10300-10305.

Corsi-Cabrera, M., Guevara, M. A., & del Río-Portilla, Y. (2008). Brain activity and temporal coupling related to eye movements during REM sleep: EEG and MEG results. *Brain Research, 1235,* 82-91.

Creutzfeldt, O. D. (1995). *Cortex cerebri: Performance, structural and functional organization of the cortex.* Oxford: Oxford University Press.

Daher, F., & Mattioli, R. (2015). Impairment in the aversive memory of mice in the inhibitory avoidance task but not in the elevated plus maze through intra-amygdala injections of histamine. *Pharmacology, Biochemistry and Behavior, 135,* 237-245

Damasio, A. R. (1999). *The feeling of what happens: body and emotion in the making of consciousness.* New York: Harcourt Brace.

Delvenne, J.-F., Seron, X., Coyette, F., & Rossion, B. (2004). Evidence for perceptual deficits in associative visual (prosop) agnosia: A single-case study. *Neuropsychologia, 42,* 597–612.

Capitani, E., Laiacona, M., Pagani, R., Capasso, R., Zampetti, P., & Miceli, G. (2009). Posterior cerebral artery infarcts and semantic category dissociations: A study of 28 patients. *Brain: A Journal of Neurology, 132,* 965-965.

Gahagan, L. (1936). Sex differences in recall of stereotyped dreams, sleep-talking, and sleep-walking. *The Pedagogical Seminary and Journal of Genetic Psychology, 48,* 227-236.

Geroldi, C., Akkawi, N. M., Galluzzi, S., Ubezio, M., Binetti, G., Zanetti, O., Trabucchi, M., & Frisoni, G. B. (2000). Temporal lobe asymmetry in patients with Alzheimer's disease with delusions. *Journal of Neurology, Neurosurgery and Psychiatry, 69,* 187-191.

Geroldi, C., Bresciani, L., Zanetti, O., & Frisoni, G. B. (2002). Regional brain atrophy in patients with mild Alzheimer's disease and delusions. *International Psychogeriatrics, 14,* 365-378.

Gloor, P. (1990). Experiential phenomena of temporal lobe epilepsy: Facts and hypotheses. *Brain: A Journal of Neurology, 113,* 1673-1694.

Gloor, P., Olivier, A., Quesney, L. F., Andermann, F., & Horowitz, S. (1982). The role of the limbic system in experiential phenomena of temporal lobe epilepsy. *Annals of Neurology, 12,* 129-144.

Griffith, R. M., Miyagi, O., & Tago. A. (1958). Universality of typical dreams: Japanese vs. Americans. *American Anthropologist, 60,* 1173–1179.

Hartmann, E. (2000). We do not dream of the 3 R's: Implications for the nature of dreaming mentation. *Dreaming, 10,* 103-110.

Hobson, J. A. (1988). *The dreaming brain.* New York: Basic Books, Inc.

Hobson, J. A., & McCarley, R. W. (1977). The brain as a dream state generator: An activation-synthesis hypothesis of dream process. *The American Journal of Psychiatry, 134,* 1335–1348.

Hong, C. C. H., Gillin, J. C., Dow, B. M., Wu, J., & Buchsbaum, M. S. (1995). Localized and lateralized cerebral glucose metabolism associated with eye movements during REM sleep and wakefulness: A positron emission tomography (PET). *Sleep, 18,* 570-580.

Izquierdo, I., & Medina, J. H. (1993). Role of the amygdala, hippocampus and entorhinal cortex in memory consolidation and expression. *Brazilian Journal of Medical Biological Research, 26,* 573-89.

Jonin, P. Y., Noel, A., Trebon, P., Vichard, H., Merck, C., & Belliard, S. (2013). Towards a left MTL specialization for arbitrary-associative learning? A multiple-case study. *Behavioural Neurology, 26,* 211-213.

Jouvet, M. (1962). Recherches sur les structures nerveuses et les mechanismes responsables des differentes phases du sommeil physiologique. (Research on the neural structures and responsible mechanisms in different phases of physiological sleep.) *Archives Italiennes de Biologie, 100,* 125-206.

Karnath, H. O., Rüter, J., Mandler, A., & Himmelbach, M. (2009). The anatomy of object recognition – Visual form agnosia caused by medial occipitotemporal stroke. *The Journal of Neuroscience, 29,* 5863-5872.

Konen, C. S., Behrmann, M., Nishimura, M., & Kastner, S. (2011). The functional neuroanatomy of object agnosia: A case study. *Neuron, 71,* 49-60.

Krystal, J. H., Perry, E. B. Jr., Gueorguieva, R., Belger, A., Madonick, S. H., Abi-Dargham, A., Cooper, T. B., MacDougall, L., Abi-Saab, W., & D'Souza, D. C. (2005). Comparative and interactive human psychopharmacologic effects of ketamine and amphetamine: Implications for glutamatergic and dopaminergic model psychoses and cognitive function. *Archives of General Psychiatry, 62,* 985-995.

Law, J. R., Flanery, M. A., Wirth, S., Yanike, M., Smith, A. C., Frank, L. M., Suzuki, W. A., Brown, E. N., & Stark, C. E. L. (2005). Functional magnetic resonance imaging activity during the gradual acquisition and expression of paired-associate memory. *The Journal of Neuroscience, 25,* 5720-5729.

Leu-Semenescu, S., Uguccioni, G., Golmard, J.-L., Czernecki, V., Yelnik, J., Dubois, B., d'Arc, B. F., Grabli, D., Levy, R., & Arnulf, I. (2013). Can we still dream when the mind is blank? Sleep and dream mentations in auto-activation deficit. *Brain: A Journal of Neurology, 136,* 3076-3084.

Maggiolini, A., Cagnin, C., Crippa, F., Persico, A., & Rizzi, P. (2010). Content analysis of dreams and waking narratives. *Dreaming, 20,* 60-76.

Maggiolini, A., Lazzaroni, E., & Crippa, F. (2012). I contenuti tipici dei sogni. Una ricerca su sogni e narrative diurne di adolescenti e giovani adulti. (Typical contents of dreams. A research on dreams and waking narratives of adolescents and young adults.) *Infanzia e Adolescenza, 11,* 113-124.

Maquet, P., Peters, J.-M., Aerts, J., Delfiore, G., Degueldre, C., Luxen, A., & Franck, G. (1996). Functional neuroanatomy of human rapid-eye-movement sleep and dreaming. *Nature, 383,* 163-166.

Mathes, J., & Schredl, M. (2014). Analyse einer großen Stichprobe von Träumen aus Tagebüchern - Wie typisch sind diese typische Träume? (Analysis of a large sample of diary dreams - how typical are these typical dreams?) *Somnologie, 18,* 107-112.

Mathes, J., Schredl, M., & Göritz, A. S. (2014). Frequency of typical dream themes in most recent dreams: An online study. *Dreaming, 24,* 57-66.

McCarthy, R. A., & Warrington, E. K. (1986). Visual associative agnosia: A clinico-anatomical study of a single case. *Journal of Neurology, Neurosurgery and Psychiatry, 49,* 1233–1240.

Morrison, A. R., Sanford, L. D., Ball, W. A., Mann, G. L., & Ross, R. J. (1995). Stimulus-elicited behavior in rapid eye movement sleep without atonia. *Behavioral Neuroscience, 109,* 972-979.

Moscarello, J. M., & LeDoux, J. E. (2013). Active avoidance learning requires prefrontal suppression of amygdala-mediated defensive reactions. *The Journal of Neuroscience, 33,* 3815-3823.

Nielsen, T. A., Zadra, A. L., Simard, V., Saucier, S., Stenstrom, P., Smith, C., & Kuiken, D. (2003). The typical dreams of Canadian university students. *Dreaming, 13,* 211-235.

Ojemann, G. A., & Schoenfield-McNeill, J. (1998). Neurons in human temporal cortex active with verbal associative learning. *Brain and Language, 64,* 317-327.

Panksepp, J. (1998a). *Affective neuroscience: The foundations of human and animal emotions.* New York: Oxford University Press.

Panksepp, J. (1998b). The periconscious substrates of consciousness: Affective states and the evolutionary origins of the SELF. *Journal of Consciousness Studies, 5,* 5-6.

Panksepp, J., Asma, S., Curran, G., Gabriel, R., & Greif, T. (2012). Philosophical implications of affective neuroscience. *Journal of Consciousness Studies, 19,* 6-48.

Parvizi, J., & Damasio, A. (2001). Consciousness and the brainstem. *Cognition, 79,* 135–160.

Parvizi, J., & Damasio, A. (2003). Neuroanatomical correlates of brainstem coma. *Brain: A Journal of Neurology, 126,* 1524-1536.

Penfield, W. (1958). *The excitable cortex in conscious man.* Liverpool: University Press.

Penfield, W., & Rasmussen, T. (1955). *The cerebral cortex of man: A clinical study of localization of function.* New York: Macmillan.

Poza, J. J., & Martí Massó, J. F. (2006). Total dream loss secondary to left temporo-occipital brain injury. *Neurologia, 21,* 152-154.

Prelevic, S., Burnham, W. M., & Gloor, P. (1976). A microelectrode study of amygdaloid afferents: Temporal neocortical inputs. *Brain Research, 10,* 437-457.

Rossion, B., Caldara, R., Seghier, M., Schuller, A.-M., Lazeyras, F., & Mayer, E. (2003). A network of occipito-temporal face-sensitive areas besides the right middle fusiform gyrus is necessary for normal face processing. *Brain: A Journal of Neurology, 126,* 2381-2395.

Schiltz, C., Sorger, B., Caldara, R., Ahmed, F., Mayer, E., Goebel, R., & Rossion, B. (2006). Impaired face discrimination in acquired prosopagnosia is associated with abnormal response to individual faces in the right middle fusiform gyrus. *Cerebral Cortex, 16,* 574-586.

Schredl, M., Ciric, P., Götz, S., & Wittmann, L. (2004). Typical dreams: Stability and gender differences. *Journal of Psychology, 138,* 485-494.

Silani, G., Lamm, C., Ruff, C. C., & Singer, T. (2013). Right supramarginal gyrus is crucial to overcome emotional egocentricity bias in social judgments. *The Journal of Neuroscience, 25,* 15466-15476.

Smith, M. L., Bigel, M., & Miller, L. A. (2011). Visual paired-associate learning: In search of material-specific effects in adult patients who have undergone temporal lobectomy. *Epilepsy and Behavior, 20,* 326-330.

Solms, M. (1995). New findings on the neurological organization of dreaming: Implications for psychoanalysis. *Psychoanalytic Quarterly, 64,* 43–67.

Solms, M. (1997). *The neuropsychology of dreams: A clinico-anatomical study.* Hillsdale, NJ: Erlbaum.

Steeves, J., Dricot, L., Goltz, H. C., Sorger, B., Peters, J., Milner, A. D., Goodale, M. A., Goebel, R., & Rossion, B. (2009). Abnormal face identity coding in the middle fusiform gyrus of two brain-damaged prosopagnosic patients. *Neuropsychologia, 47,* 2584-2592.

Tost, H., Ruf, M., Schmäl, C., Schulze, T. G., Knorr, C., Vollmert, C., Bößhenz, K., Ende, G., Meyer-Lindenberg, A., Henn, F. A., & Rietschel, M. (2010). Prefrontal-temporal gray matter deficits in bipolar disorder patients with persecutory delusions. *Journal of Affective Disorders, 120,* 54-56.

Turner, B. H., Mishkin, M., & Knapp, M. (1980). Organization of the amygdalopetal projections from modality specific association areas in the monkey. *Journal of Comparative Neurology, 191,* 515-543.

Vignal, J.-P., Maillard, L., McGonigal, A., & Chauvel P. (2007). The dreamy state: hallucinations of autobiographic memory evoked by temporal lobe stimulations and seizures. *Brain: A Journal of Neurology, 130,* 88-99.

Vollenweider, F. X., Vontobel, P., Øye, I., Hell, D., & Leenders, K. L. (2000). Effects of (S)-ketamine on striatal dopamine: A [$^{11}$C] raclopride PET study of a model psychosis in humans. *Journal of Psychiatric Research, 34,* 35-43.

Whalley, H. C., Gountouna, V. E., Hall, J., McIntosh, A., Whyte, M.-C., Simonotto, E., Job, D. E., Owens, D. G. C., Johnstone, E. C., & Lawrie, S. M. (2007). Correlations between fMRI activation and individual psychotic symptoms in un-medicated subjects at high genetic risk of schizophrenia. *BMC Psychiatry, 7,* 61.

Whitlok, D. G., & Nauta, W. J. (1956). Subcortical projections from the temporal neocortex in Macaca mulatta. *Journal of Comparative Neurology, 106,* 183-212.

Wilensky, A. E., Schafe, G. E., & LeDoux, J. E. (2000). The amygdala modulates memory consolidation of fear-motivated inhibitory avoidance learning but not classical fear conditioning. *The Journal of Neuroscience, 15,* 7059-7066.

Yu, C. K.-C. (2001a). Neuroanatomical correlates of dreaming: The supramarginal gyrus controversy (dream work). *Neuro-Psychoanalysis, 3,* 47-59.

Yu, C. K.-C. (2001b). Neuroanatomical correlates of dreaming, II: The ventromesial frontal region controversy (dream instigation). *Neuro-Psychoanalysis, 3,* 193-201.

Yu, C. K.-C. (2003). Neuroanatomical correlates of dreaming, III: The frontal-lobe controversy (dream censorship). *Neuro-Psychoanalysis, 5,* 159-169.

Yu, C. K.-C. (2005). A paradox of studying dream alteration in patients with pontine lesions. *Neuro-Psychoanalysis, 7,* 85-90.

Yu, C. K.-C. (2006a). Commentary on Simon Boag's 'Freudian dream theory, dream bizarreness, and the disguise-censor controversy'. *Neuro-Psychoanalysis, 8,* 53-59.

Yu, C. K.-C. (2006b). Memory loss is not equal to loss of dream experience: A clinicoanatomical study of dreaming in patients with posterior brain lesions. *Neuro-Psychoanalysis, 8*, 191-198.

Yu, C. K.-C. (2007). Cessation of dreaming and ventromesial frontal-region infarcts. *Neuro-Psychoanalysis, 9,* 85-92.

Yu, C. K.-C. (2008). Typical dreams experienced by Chinese people. *Dreaming, 18,* 1-10.

Yu, C. K.-C. (2009a). Delusions and the factor structure of typical dreams. *Dreaming, 19,* 42-54.

Yu, C. K.-C. (2009b). Paranoia in dreams and the classification of typical dreams. *Dreaming, 19,* 255-272.

Yu, C. K.-C. (2010). Recurrence of typical dreams and the instinctual and delusional predispositions of dreams. *Dreaming, 20,* 254-279.

Yu, C. K.-C. (2011). The constancy of typical dreams. *Asia Pacific Journal of Counselling and Psychotherapy, 2,* 51-70.

Yu, C. K.-C. (2012). Dream Motif Scale. *Dreaming, 22,* 18-52.

Yu, C. K.-C. (2015a). A high-density electroencephalographic study of synchronous networks during rapid-eye-movement sleep. *Dreaming, 25,* 1-17.

Yu, C. K.-C. (2015b). One hundred typical themes in most recent dreams, diary dreams, and dreams spontaneously recollected from last night. *Dreaming, 25,* 206-219.

Zinn, C. G., Bevilaqua, L. R., Rossato, J. I., Medina, J. H., Izquierdo, I., & Cammarota, M. (2009). On the requirement of nitric oxide signaling in the amygdala for consolidation of inhibitory avoidance memory. *Neurobiology of Learning and Memory, 91,* 266-272.