A model of the Dream-Building System based on phenomenological data

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Summary. The article describes a model of how our brain constructs a dream and what functions are involved in this construction. The model is based on phenomenological data, reported in the literature, obtained by experimental research focused on the relationship between the dream experience and events in the dreamer's waking life. The Dream-Building System is described as a cascade of two sub-systems. The first (the Retrieving Sub-System) performs the function of retrieving, from among the memory contents in the dreamer's mind, those specific memories that are appropriate for the construction of a dream. The output of this sub-system, i.e., a Cluster of Dream Sources, is the input of the Plot-Building Sub-System, which creates the serial plot of the Dream Experience by transforming its distributed input (i.e., the output of the Retrieving Sub-System) into a serial output. Both sub-systems perform complex functions that require a high level of creative unconscious "intelligence". Issues regarding typical dreams, underlying emotions, symbolism, condensation, creativity, and bizarreness are discussed in the light of the proposed model.

Keywords: The Dream-Building System; dream associations; dream sources; parallelism vs. seriality in dreams; dreams and creativity

1. Introduction

How does our brain build a dream? What functions are involved in the construction of a dream? This paper addresses these questions in the light of phenomenological data obtained by experimental dream research focusing on the relationship between the dream experience and its sources, which are mental contents derived from waking events. The dream building process is described herein in terms of psychological functions, without attempting to provide references to the underlying anatomo-physiological systems. Only experimental data that have been reported in the literature are considered, without analyzing new data.

The system responsible for the construction of a dream can be viewed in simple, effective terms as a system whose input is memory sources in the dreamer's mind and whose output is the dream experience (Cavallero and Cicogna, 1993). In recent years, vast research has been carried out based on the theory of continuity between waking and dreaming life (e.g., Nielsen et al., 2004; Blagrove et al., 2011; Schredl, 2012; Schredl, 2017). In the light of this theory, the dream sources are mental contents that directly refer to events in the dreamer's life. A powerful way of exploring the connections between the input and output of the system consists in asking the dreamer for associations with the items of the dream report. These associations are often characterized by detailed precise correspondences that confirm the validity of the method.

A fundamental property of the dream sources is in their marked interconnections, both conceptual and emotional: "Dreaming makes connections more broadly than waking in the nets of the mind. (…) The connections are not made in a random fashion but are guided by the dreamer's emotion." (Hartmann, 1996; see also Hartmann, 2010). Significant network properties characterize graphs whose nodes are the recognized dream sources and whose arcs are the emotional/conceptual links between pairs of them (Barcaro & Carboncini, 2018). Among these properties are a high degree of connectivity, small-word features, forms of self-similarity, and presence of "hubs" (i.e., sources directly linked to numerous other sources).

This paper is organized as follows. Section 2 indicates the four dream properties that constitute the phenomenological basis of the model. Section 3 describes the input-output model that accounts for these phenomena. Section 4 provides a simple example. Section 5 discusses some properties of the model.

2. The phenomenological basis of the model

The phenomenological basis of the model consists of four phenomena that have been observed within the framework of the continuity hypothesis between waking and dreaming life. Their general occurrence presents high statistical significance (Barcaro et al., 2016). These phenomena are:

1. "Pervasive links" exist, i.e., semantic links that connect a plurality of sources.
2. The following "heuristic rule" can account for the construction of links between sources: they are such that the dreamer's present concerns are made less negative or even reversed into positive.
3. After an initially identified present concern, a second more important one can be recognized (this phenomenon has been called "shift of the present concern").
4. The dream experience fulfills a "representative function": the overcoming of negative contents is actually represented in the dream.

The first three phenomena are directly related to the connections between dream sources, which are provided by distributed processing, while the fourth phenomenon is related to the serial plot of the dream experience.

These four points have been suggested by and are in agreement with results provided by a vast amount of research carried out in the last few decades. Point 1 is related to the above underlined dream property of creating connections. Points 2 and 4 are related on one hand to the basic importance of emotional contents (observed in numerous studies, including Piccione et al., 1977, Domhoff, 2001, Nielsen & Stenstrom, 2005, Malinowski & Horton, 2014) and on the other hand to the data that have led to hypotheses of emotionally positive functions of dreams, in particular a mood regulatory function (Kramer, 1993) and a "psychotherapeutic" function (Hartmann, 1995). Points 3 is related to the fact that present concerns are generally multiple and that in the construction of a dream one of them ("dominant emotional concern", Hartmann, 1996) fulfills a prevalent role. According to Domhoff (2001) a "repetition principle", rooted in past emotional preoccupations, adds to a "continuity principle" linked to current concerns.

A methodological clarification: Although the heuristic rule (point 2) somehow resembles the idea of wish fulfillment at the basis of Freudian theory, the identification and analysis of the four phenomena are independent from Freudian theory. More generally, some important concepts introduced by Freud (e.g., the idea of "condensation", which we will resume later) can be credited with phenomenological validity that is independent from the general validity of Freudian theory.

3.   The Dream-Building System

In the light of the experimental phenomena described in the previous section, the Dream-Building System can be viewed as consisting of two subsystems. The first (the Retrieving Sub-System) fulfills the function of retrieving, from among the memory contents, those that are appropriate for the construction of the dream. The output of this subsystem, i.e., a Cluster of Dream Sources, is the input of the Plot-Building Sub-System, which creates the serial plot of the Dream Experience by transforming its distributed input (i.e., the output of the Retrieving Sub-System) into a serial output.

Fig. 1 schematically shows how the Retrieving Sub-System works. The dreamer's present concerns appear to constitute the starting point for the construction of a dream. We can wonder why these concerns are generally more than one. A simple hypothesis is that the reason is economical in nature: it is more efficient for the Dream-Building System to deal with two (or even more) issues than with one. A second point is that, since the present concerns are very often connected, dealing with one can imply dealing with the other(s). A further hypothesis is that one present concern works as a screen by partially concealing the other(s): This is suggested by the fact that one concern is generally immediately expressed by the associations, while the identification of the other(s) is delayed.

The Retrieving Sub-System explores the memory content in the brain according to complex Criteria for Relevance: not only are the retrieved sources related (conceptually and emotionally) to the present concerns (or at least one of them), but they also have the property of offering a solution, a change of what is negative into something less negative or positive (in accordance with the "heuristic rule", point 2 in the list in Section 1). A third Criterion for Relevance accounts for the high degree of interconnection between the dream sources: the more closely a candidate source is linked to the other sources, the more relevant it is. Among the implications of this third criterion is that the pattern of dream sources often expresses the close underlying relationship between the present concerns.

Certainly, applying these three Criteria for Relevance requires great unconscious "intelligence" on the part of the Retrieving Sub-System. Slightly simplifying, we can say that this sub-system applies logical criteria to emotional content. This process is totally unconscious. The dreamer is certainly aware of the events that are related to the memory sources of a dream. However, the role of these events in providing the memory sources for the dream construction is only recognized if, after the dreaming experience, the dreamer is asked for associations (or reflects on the dream by himself/herself). Indeed, the Retrieving Sub-System exerts a creative function, because it creates a highly interconnected pattern that is completely new, although its elements belong to the set of memories in the dreamer's mind.

Fig. 2 adds the Plot-Building Sub-System to the diagram of Fig. 1, thus thoroughly showing how the Dream-Building System works. The output of the Retrieval Sub-System (i.e., the Cluster of Dream Sources) is the input of the Plot-Building Sub-System, which transforms the distributed input into a serial output (i.e., the plot of the Dream Experience). Although the constraints given by the bottleneck structure of this system imply that some elements of the Cluster of Dream Sources are necessarily sacrificed, the Plot-Building System is however able to convey information about the sources and to exert the "representative function" (the fourth point in the list in Section 2), i.e., to actually represent the overcoming of the present concerns. For this sub-system as well, we can speak of a high degree of unconscious "intelligence".

The transformation from distributed to serial corresponds to the transformation from unconscious to conscious, and
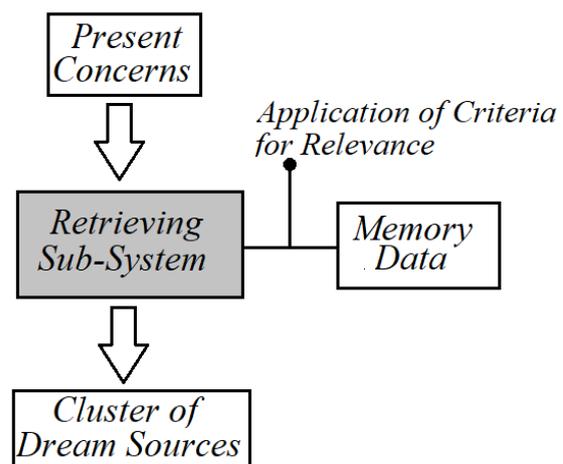

Figure 1. The Retrieving Sub-System. On the basis of the dreamer's Present Concerns, this Sub-System explores the Memory Data in the brain and selects appropriate sources by applying complex Criteria for Relevance. The output consists in a closely interconnected Cluster of Dream Sources.

precisely to the particular form of consciousness proper of the dreaming state. The association of parallelism with unconsciousness and the association of seriality with consciousness appear to be very general with regard to the workings of human mind: "The capacity of consciousness at any given moment seems limited to one consistent scene. The flow of such scenes is serial, in contrast with the massive parallelism of the brain as observed directly."(Baars et al., 2013).

4. An example

As we have stated above, both components of the Dream-Building System perform complex operations that require a high level of unconscious "intelligence". The workings of the system can be made clearer if a precise dream is considered as a basic example. We will use for this purpose a dream reported by Freud ("The Dream of the Murders on a Train", Freud, 1973, 233-234; this dream was also analyzed in Barcaro et al., 2005). The reason for choosing this dream is that its simplicity, both in the report and in the associations, renders it particularly useful, also considering that in the Freudian account a very small role is played by the prop-

Figure 2. The Dream-Building System consists of a cascade of the Retrieving Sub-System and the Plot-Building Sub-System. The latter sub-system elaborates the Cluster of Dream Sources created by the Retrieving Sub-System and provides the plot of the dreaming experience. This transformation from distributed to serial corresponds to the transformation from unconscious to conscious, specifically to the particular form of consciousness proper of the dreaming state.

er Freudian Unconscious, an item which is out of the scope of the phenomenological model described here. Of course, it would also be interesting to consider dreams characterized by more complex patterns obtained by a thorough application of the association method (e.g., among the numerous instances, the "Dream of the House in the Courtyard", Barcaro et al., 2005, and "The Dream of a Doctor Wearing a White Coat", Barcaro et al., 2019; we will briefly refer to these dreams in the next Section). However, for the sake of simplicity, we limit ourselves here to "The Dreamer of the Murders on a Train", for which only four sources were identified. Quoting from the Freudian text, these sources were:

Source S1: "He [the dreamer] thought of a story told him by a friend. A lunatic was being conveyed in a compartment on an Italian line, but through carelessness a traveler was allowed in with him. The madman killed the other traveler."

Source S2: "At the theater the night before he had once more seen the girl he had wanted to marry but had withdrawn from because she had given him ground for being jealous. (...) He regarded her as so untrustworthy that, in his jealousy, he would have to kill everyone who came his way."

Source S3: "Once when he was on a railway journey there had been a sudden stop of this kind when they were not in a station. A young lady who was traveling with him had said that there might be going to be a collision and that the safest thing to do was to lift one's legs high."

Source S4: "But this 'lifting the legs high' had also played a part in the many walks and excursions in the country which he had taken with the other girl in the happy early days of their love."

The two present concerns that prompted this dream were the jealousy about the girl that the dreamer had wanted to marry, and the mental condition ("madness") of the dreamer.

S1 was linked both to the madness issue and to the jealousy issue ("he would have to kill everyone who came his way"). Thus, according to the Criteria for Relevance, S1 had a high relevance. Both S2 and S4 were clearly related to the girl issue. S1 offered a solution to both the present concerns, because the madman succeeded in performing his desire of killing: The idea of killing, although morally negative, was highly positive from the point of view of the dream construction. S2 was the memory of a recent event that emotionally rekindled the jealousy concern without, at least at first sight, offering a solution. On the other hand, a solution was given by S4, closely linked to S2, because of the role of young girls in both events: The concern provoked by the dreamer's jealousy was thus alleviated, if not reversed, by underlining the pleasure that he had felt when being with that girl in the open country. As a result, the link with S4 increased the relevance of S2.

Certainly, the identification of Sources S2, S3, and S4 shows the great "intelligence" of the Dream-Building System in finding appropriate sources for the conceptual/emotional changes expressed by the heuristic rule. A further form of "intelligence" is highlighted by Source S3, the memory of an event with multiple links to the other sources: this event occurred in a "train" (link L13 between S3 and S1), during a stop in the "country" (link L34a between S3 and S4), with the presence of a "young girl" (Link L234 between S3, S2, and S4) who spoke about lifting the "legs high" (link L34b between S3 and S4). All these links involve S3, a source that fulfills the role of a proper "hub". The only link that does not
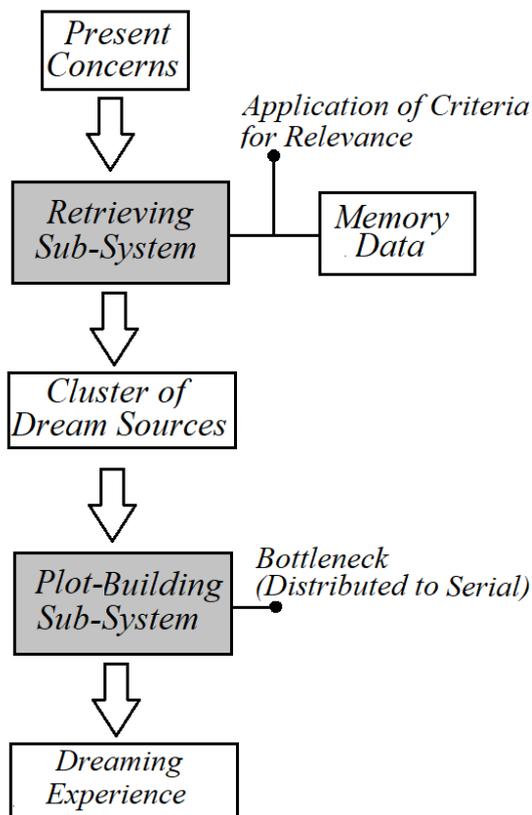
involve S3 is L12, given by the idea of "killing", which connects S1 and S2.

If a graph is drawn (Fig. 3) whose nodes are the sources and whose arcs are the links between them, this graph (in technical terms, a "multigraph", because different arcs are allowed to connect any pair of nodes) presents a high degree of connection (in other words, a unitary structure). The central triangle corresponds to the "pervasive link" L234 (point 1 in the list of Section 2).

The dream report was the following: "He was traveling in a railway-train. The train came to a stop in open country. He thought there was going to be an accident and that he must think of getting away. He went through all the coaches in the train and killed everyone he met—the guard, the engine-driver, and so on." In the dream report, the item "killing" conveyed information about Sources 1 and 2, the item "train" conveyed information about Sources 1 and 3, and the item "country" conveyed information about Sources 3 and 4. Although the bottleneck sacrificed the links "young girl" and "leg high", information about all the sources was thus conveyed. The Plot-Building Sub-System effectively performed a successful management of the two present concerns: the action of killing showed that madness could present positive aspects and at the same time actually fulfilled the dreamer's aggressive desire connected with his jealousy. The choice of the sacrificed elements was very "intelligent" on the part of this sub-system: No young girl was present in the train, thus the girl he has wanted to marry was far from being killed and consequently he could again have pleasant experiences with her.

5. Properties of the above outlined Dream-Building System and implications regarding emotions, typical dreams, symbolism in dreams, condensation, and bizarreness.

As indicated in the Introduction, this model of dream construction is closely related to Hartmann's approach to the study of dreams (1996, 2010), which in turn is related to
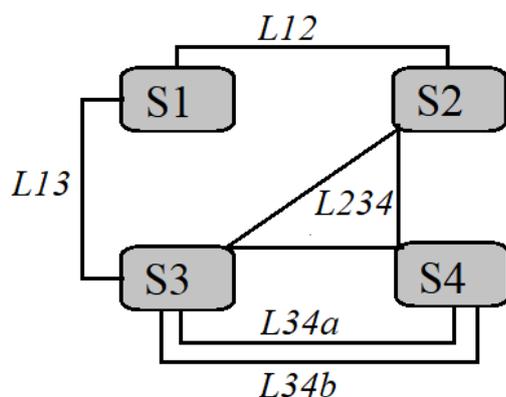

Figure 3. Multigraph representation of the dream-source pattern for the "Dream of the Murder on a Train" reported by Freud. The nodes represent the sources and the arcs represent the conceptual/emotional links between pairs of sources. Source 3 is a "hub", because it is highly connected with all the other sources. Link L234, which determines the triangular sub-graph, is a "pervasive link", because it links more than two sources.

other significant approaches, including cognitive (especially linguistic) methods (Foulkes, 1982), connectionist models (Antrobus, 1991), and the study of dreaming as a cognitive achievement that depends on the maintainance of specific network structures (Domhoff, 2001).

A basic aspect of the above outlined Dream-Building System is that it consists of two stages. Barcaro et al. (2012) proposed a two-stage model of dream construction by separating a system responsible for the connections among sources and a second system providing the final dream experience by processing the output of the first system. According to that model, the Story-telling Method for dream analysis (DeCicco, 2007) was interpreted as an effective way of accessing the output of the first system. The system described in this paper can be viewed as an elaboration of that two-stage model on the basis of new data.

The Dream-Building System is obviously a feedback system, because the Dream Experience certainly exerts changes in the dreamer's mind, which obviously includes both the present concerns (input to the system) and the memory sources (explored by the Retrieving Sub-System). A major effect of the feedback seems to be an improvement in the dreamer's attitude towards his/her concerns. The phenomenon indicated above as "heuristic rule" clearly indicates this form of improvement.

Both sub-systems of the Dream-Building System work in a highly creative way. This creativity, which acts unconsciously, can be the basis of the frequently described use of dreams for creative problem solving, especially by artists and scientists (about this use of dreams, see Barrett, 2001).

The complexity of the functions fulfilled by both the sub-systems is in agreement with chronobiological data. For instance, Cipolli et al. (2005) observed variations in the story-like organization of dreams during the night and interpreted their results by considering that the elaboration of a complex dream-story requires a great amount of cognitive resources to maintain its continuity and coherence.

Since the Dream-Building System deals with emotional contents in a logical way, significant differences may occur between the emotions felt during the dream experience, which may directly refer to painful experiences, and the positive emotional result provided by the improvement in the dreamer's attitude towards his/her concerns. An example of this superposition is given by a dream that Charles Darwin had at the age of 29: he dreamed of a corpse coming back to life after a public execution (for an analysis of this "big" dream, see Bulkeley, 2016). Darwin's dream was prompted by a serious present concern due to the strong opposition of the social and religious institutions to his theory; however, a feeling of "banter and joking" accompanied the dream experience. Interestingly, a superposition of positive and negative emotions can also occur in other psychophysiological experiences: for instance, this often characterizes esthetic experiences (see, e.g., Brattico et al., 2016; Eerola et al., 2018).

The difference, and sometimes opposition, between emotions at different levels of the dream construction also implies that nightmares as well can play the emotionally positive role of dreaming. Indeed, an adaptive view of dream functions has been supported by studies of dreams in specific stressful situations (Breger et al., 1971; Cartwright, 1991; Hartmann, 1996).

The process performed by the Retrieving Sub-System presents some similarity with the process, performed by Internet Search Engines, of retrieving relevant information from Internet websites as a response to users' queries. Certainly, the differences are obvious; however, taking this point into account may be helpful, considering that both the Internet and the brain belong to the numerous set of important network systems, and that the use and the knowledge of the Internet are currently widespread. Internet Search Engines carry out an off-line process of building a specific database that is effective for answering users' queries. This structured database is built by acquiring data from the Internet. To obtain effective responses by analyzing this database, the user's queries are classified into appropriate categories. Something similar is likely to happen for the Retrieval Sub-System, which explores the memory content in the brain. In particular, it can be assumed that the Retrieving System can adequately apply the Criteria for Relevance by classifying the present concerns into appropriate categories.

Thus, if the Retrieving Sub-Systems creates a Cluster of Dream Sources as a response to present concerns that are classified into appropriate categories, the occurrence of typical dreams can be accounted for very simply, if we assume the dream plot reflects the categories of the present concerns that prompt the dream. From this point of view, typical dreams correspond to frequent categories of the present concerns. A trivial example: dreams about exams can be due to present concerns classified as belonging to a category somehow related to the idea of current difficult tasks.

In close agreement with the theory of continuity between awake and dreaming life, the model described herein of the Dream-Building System focuses on the connections between the dream items and specific events in the dreamer's life, rather than directly considering a possible symbolic meaning of the dream items. Indeed, in the application of the association method, associations having the character of general assertions are generally (if not always) followed, and thus made more precise and detailed, by references to specific events in the dreamer's life. For instance, in the associations that the dreamer provided regarding "The Dream of the House in the Courtyard", the assertion "Night and cold are two sad, gloomy things", which attributed an unspecific symbolic value to the idea of "night and cold", was followed by the reference to the dreamer's sadness about her grandfather's illness.

The items of a dream often assume multiple valences. Freud defined "condensation" as "latent elements which have something in common being combined and fused into a single unit in the manifest dream" (Freud, 1973, pp. 205-206). The general occurrence and great importance of this phenomenon has been confirmed by current experimental research. For instance, the title of Chapter 7 of Hartmann's book (2010) connects condensation with the general dream property of making connections: "Connection as combination; connection as condensation; connection as metaphor; the dream as picture- metaphor". The phenomenon of condensation can be accounted for by the bottleneck structure of the Plot-Building Sub-System. To overcome the constraints due to the bottleneck structure, this sub-system exerts a form of (unconscious) "intelligence" not only in choosing what elements to sacrifice avoiding loss of information, but also in privileging items that present a high information content, i.e., items that correspond to a plurality of elements of the Cluster of Dream Sources.

A large amount of condensation (in other words, a significant achievement of the Plot-Building System) can determine a bizarre item in the Dream Experience. An example is given by "The Dream of a Doctor in a White Coat" (Barcaro et al., 2016) that was prompted by two present concerns respectively related to a current health problem that caused some difficulty in moving, and to the memory of skating experiences: this dream ended with the bizarre item of the dreamer skating fast along the spaces between beds in a room where she was being visited.

Among the capabilities of the Plot-Building Sub-System is that of being able to apply the "heuristic rule" to even opposite present concerns. An example is given by the "Dream of the House in the Courtyard" (Barcaro et al. 2005): the dreamer's two identified present concerns were respectively characterized by love for grandfather and hostility to grandfather's proposal of coming back to their old house. The dreamer found herself in the country, close to a house identified as the old house; the atmosphere was very sad (thus expressing her concern for grandfather's illness); and finally the dreamer left (thus expressing her disagreement with grandfather's wish and fulfilling her own wish).

6. Short conclusion

A model is proposed of how our brain builds a dream and what functions are implied in this construction. It is based on phenomenological data obtained by experimental dream research. According to this model, the Dream-Building System consists of a cascade of two sub-systems. The first retrieves, from among the memory sources in the dreamer's mind, those that are appropriate for dream constructions, thus creating a complex interconnected pattern of dream sources. The second sub-system elaborates this pattern in order to obtain the serial plot that constitutes the dream experience. The functions performed by both these sub-systems require a high level of unconscious "intelligence". Significant issues can be interestingly dealt with in the light of the model. Among these issues are the role of emotions, the hypothesis of a mood-regulatory function of dreams, the occurrence of typical dreams, the diffused phenomenon of condensation, the possible presence of bizarre items, and the role of creativity in dream construction.

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