Continuity in studying the continuity hypothesis of dreaming is needed

Reply to the comments on "The continuity and discontinuity between waking and dreaming: A dialogue between Michael Schredl and Allan Hobson concerning the adequacy and completeness of these notions"

Michael Schredl

Central Institute of Mental Health, Mannheim, Germany

Summary. The ten commentaries to my discussion with J. Allan Hobson about the continuity and discontinuity between waking and dreaming (Hobson & Schredl, 2011) are very stimulating and I would like to thank all contributors. This reply will focus on four aspects: Defining continuity and discontinuity, how does the relationship between waking and dreaming work, possible functions of dreaming, and how to study the continuity (or lack of) between waking and dreaming empirically. Even though the question about possible functions is the most interesting one, I believe that much research is needed before this enigma can be solved. As dream research is such a small field, it is necessary that researchers discuss their theories openly and replicate each other's findings, applying different methodological approaches for studying the same phenomena.

First, I would like to thank all the fellow researchers who contributed commentaries to my discussion with J. Allan Hobson about the continuity and discontinuity between waking and dreaming (Hobson & Schredl, 2011). The ten commentaries are very stimulating and clearly indicate that current research – despite of the growing literature – is still at the beginning and that lot of work has yet to be done to understand the continuities and discontinuities between waking and dreaming.

My reply will focus on four aspects: Defining continuity and discontinuity, how does the relationship between waking and dreaming work, possible functions of dreaming, and how to study the continuity (or lack of) between waking and dreaming empirically.

Definition of continuity

Regarding definition, I was glad that Bill Domhoff reviewed the work of Calvin S. Hall and co-workers who studied the continuity between waking and dreaming intensely in his commentary (Domhoff, 2011). Although Domhoff mentioned the early work of Hall, he did not refer explicitly to the publication that specifically dealt with the continuity hypothesis of dreaming as seen by Calvin Hall (Hall & Nordby, 1972). Since what he wrote elucidate the involved definition problems quite nicely, I will quote two passages of his book:

"These facts and many others obtained from the content analysis of many dream series have led us to formulate what we call the continuity hypothesis. This hypothesis states that dreams are continuous with waking life; the world of dreaming and the world of waking are one. The dream world is neither discontinuous nor inverse in its relationship to the conscious world. We remain the same person, the same personality with the same characteristics, and the same basic beliefs and convictions whether awake or asleep. The wishes and fears that determine our actions and thoughts in everyday life also determine what we will dream about.

How can we reconcile the continuity hypothesis with the obvious fact that a person will do something in his dreams that he would not or could not do in a waking state? He will, for example, torture someone to death, have sex with his young daughter, betray his best friend, or fly through the air.

The answer to this dilemma is to be found in the distinction between overt behavior ("acting out") and covert behavior (thoughts, feelings, and fantasies). The continuity may be between dreams and covert behavior or it may be between dreams and overt behavior. A person who has many sex or aggression dreams may either have many fantasies of sex or aggression when he is awake, or he may have many actual sexual or aggressive experiences. In either case he is preoccupied with sex or aggression, awake or asleep. Although when asleep these preoccupations have fewer limitations, allowing the dreamer to experience tremendous diversity in his sexual and aggressive fantasies. (p. 104, Hall & Nordby, 1972) "

"The evidence presented in this chapter substantiates the continuity hypothesis. There is considerable congruence between what a person dreams about at night and what he does or thinks about when he is awake. The distinction between doing and thinking (or fantasying) enables us to reconcile the continuity hypothesis with the popular idea that dreams compensate for desires which remain unfulfilled in waking life. (p. 125-126, Hall & Nordby, 1972)"

The explanations given by Hall and Nordby (1972) clearly indicate that the continuity hypothesis was defined very broadly and clearly goes beyond the notions of conceptions and concerns suggested by Domhoff as the most important aspects of continuity. In Table 1, I compiled waking-life aspects which have been suggested by different authors to be continuous to dreaming. These aspects can be grouped into

Corresponding address:
Prof. Dr. Michael Schredl, Sleep laboratory, Central Institute of Mental Health, PO Box 122120, 68072 Mannheim, Germany.
Email: Michael.Schredl@zi-mannheim.de

the two broad categories "covert" and "overt" behavior as mentioned above by Hall and Nordby (1972). These aspects do not exclude each other; they rather contribute together to the relationship between waking and dreaming. Let me illustrate this by using an example given by Hall (1953): *"If the dreamer feels that the world presents a cold, bleak face, he may materialize this conception in the form of a cold climate and a bleak, rocky setting (in the dream). p. 277"* This example should illustrate how conceptions of the world might be reflected in dreams. If you look at the experiential level, one might expect that such a person experiences distance in relationships, might have very few intimate friends and so on. I.e., these experiences are also reflected in dreams where the dreamer is alone in a bleak, rocky setting. The similar argument can be made for emotions, feelings of loneliness in the waking state are directly reflected in such dream images – even though there might be no continuity regarding dream content. This kind of relationship was nicely shown in the qualitative study of Malinowski and Horton (2011). Tadas Stumbrys (2011) emphasized a type of continuity rarely looked at by other dream researchers: the aspect of meta-awareness. The induction of lucid dreaming by using the reflection technique ("Am I dreaming or am I awake?") is based on this continuity, i.e., increasing reflective awareness about one's state of consciousness during waking increases the awareness while dreaming and, thus, can increase lucidity. The findings that meditators experience lucid dreams more often corroborate this idea (Reed, 1978).

To summarize this section, I posit that many different aspects of waking life can show up in dreams. It clearly depends on how waking-life is assessed (see below) and what the researcher's focus is.

Definition of discontinuity

As difficult as it is to define continuity precisely, the definition of discontinuity is even more problematic. There are dream contents that can easily be classified as discontinuous like flying without any aid (Schredl, 2011) or walking dreams in congenital paraplegics (Saurat, Agbakou, Attigui, Golmard, & Arnulf, 2011) because these dreams include experiences never made by the dreamer in his or her waking life. The finding that flying dreams which are generally experienced as positive are related to personality traits associated with more positive emotions in the waking life (Schredl, 2008c),

Table 1: Different aspects of waking life in relation to the continuity hypothesis

Aspects	
• Concerns	• Actions
• Conceptions	• Interests
• Thoughts	• Unfinished business
• Emotions	• Psychological issues
• Experiences	• Worries
• Preoccupations	• Personal significant events
• Fantasies	• Meta-awareness

however, supports even in those dreams some kind of continuity with respect to emotions.

A completely different way of defining discontinuity is the suggestion by Allan Hobson (Hobson & Schredl, 2011) that dream elements (persons, actions, places) that are altered compared to waking life (e.g., well-knows neighborhood includes houses that are not there in reality or a friend looks different in the dream) are considered to be discontinuous to waking life. Hobson also uses the term 'autocreativity' within this context. From a viewpoint of expecting exact replays of episodic memories in dreams, this is not continuous with waking life as it happened. On the other hand, these aspects are related to the creativity of dreaming and, thus, are not 'intended' to be continuous with waking life – at least not on a thematic level (there still might be continuity on the level of emotions – see Hartmann, 2011a). In addition, Hartmann (2011a) correctly pointed out that scene-shifts, condensations, bizarreness are not discontinuous to all waking life if one considers daydreaming, reverie, and fantasy.

Another approach for defining discontinuity was suggested by David Kahn (2011) who recounted a dream of his own that was not linked to his current waking life concerns in a direct way. He termed those dreams "out of the blue" dreams. Kelly Bulkeley (2011) also mentioned this type of discontinuity dreams and linked such dreams to spiritual and religious beliefs of the dreamer, i.e., seeing again some kind of continuity between waking and dreaming. Domhoff (2011) also mentioned a group of dreams that he titled adventure stories or narrative-driven dreams because they did not include familiar characters and normal activities. Malinowski and Horton (2011) gave a simple example of how the concept of metaphor may be important when looking at these dreams. A dreamer linked the semi-failed space ship launch in the dream to her worries as to whether her career had really "taken off". Systematic research on the continuity between waking life and dreaming with respect to metaphors has been rarely done. The reported increase in phallic representations in dreams after seeing an erotic movie (Cartwright, Bernick, Borowitz, & Kling, 1969) clearly supports this line of thinking.

To summarize, I agree with David Kahn (2011) and Bill Domhoff (2011) that studying dreams with discontinuous elements is a very promising field for future research – it might be that they are not as discontinuous as previously thought, though, when taking a closer look.

How does continuity between waking and dreaming work?

Mark Blagrove (2011) pointed out that dreams might not serve any function but can still be meaningful to the dreamer – for examples in stimulating waking-life creativity (Schredl & Erlacher, 2007). I.e., before speculating about the function(s) of dreaming, the first thing to do is to look how the continuity between waking and dreaming works. There is the simple question as to what kind of waking life experiences are reflected in dreams. Hobson (Hobson & Schredl, 2011) suggested that second-order consciousness (planning, reflecting, thinking etc.) is very rare in dreams. Even though reading, writing, and arithmetic are underrepresented in dreams – even in students who are fully immersed in their academic studies (Hartmann, 2000; Schredl & Hofmann, 2003), research has shown that meta-cognition (Kahan & LaBerge, 1996) and thinking (Meier, 1993) can be found in

dreams – when elicited in appropriate ways (probing the participants after giving a free report and training dreamers to remember these kind of cognitive activities). Whether the underrepresentation of focused cognitive activities in REM dreams might be explained by reduced prefrontal brain activation is also an open empirical question, because these dream characteristics have never been linked directly to brain activation patterns during sleep using modern imaging techniques. Similarly, whether the activation levels of the amygdala during REM sleep are related to the intensity of dream emotions has not been studied. Or whether cholinergic activity is related to dream bizarreness as the AIM model (Hobson, Pace-Schott, & Stickgold, 2000) would predict. Interestingly, lucid dreaming can be stimulated by cholinergic drugs like donepezil (cf. Stumbrys, 2011).

On the other hand, research has studied factors which might affect the incorporation of waking life events into subsequent dreams like emotionality, personality, etc. (for a review see: Schredl, 2003). Personal significance might be a factor in the diary study reported by Malinowski and Horton (2011). Another line of research is looking at the time course of incorporations, the so-called dream lag effect stating that contents might re-emerge in dreams even after 5-7 days (Blagrove, Fouquet, et al., 2011). An interesting study directly compared the effect of waking experience (overt behavior in the definition of Hall and Nordby) and fantasy (covert behavior) on dreaming. The results were clear-cut: Frequency of sexual fantasies were related to the frequency of erotic dreams while the frequency of sexual encounters or masturbation frequency did not (Schredl, Desch, Röming, & Spachmann, 2009). This adds to the findings that the time spent with waking activities like sports is also an important factor for incorporation into dreams (Erlacher & Schredl, 2004; Schredl & Erlacher, 2008).

For me, this kind of research is important in order to arrive at a comprehensive model of continuity between waking and dreaming.

How can discontinuity between waking and dreaming be explained?

Whereas the continuity between waking and dreaming makes obvious sense (see the section on functions of dreaming), the discontinuous dream elements are not easily understood: Does it makes any sense that humans dream of flying or other bizarre things – things they have never experienced in their lives and never will? Domhoff (2011) posed the question as to whether these contents might be "cognitive glitches"; maybe related to the relative deactivation of the prefrontal cortex in REM sleep. In this sleep stage, the brain is hyper-associative and not capable of congruent plots and therefore sudden scene-changes, condensations (different people merged together), known settings with new elements in it and so on are likely to occur (Hartmann, 2011b; Hobson et al., 2000). As these features can also be found in daydreaming, it should be noticed that comparable phenomenology is not necessarily based on similar brain processes – as Domhoff (2011) might imply. We don't know yet whether the default network – active during "doing nothing" in the waking state – is also the key player underlying REM sleep dreaming.

The next idea is that discontinuity in content might be explained by continuity regarding emotions – positive flying dreams are related to positive waking-life (Schredl, 2008c).

Continuity on the level of metaphors have been suggested by Malinowski and Horton (2011) and Domhoff (2011) – see the above example of the launch of a space ship. However, these relationships have not been studied systematically – most material in the literature is based on clinical cases where dreams were – with the help of the therapist – related to the dreamer's current life. In one of his early publications, Calvin Hall (1951) hypothesized that strangers in dreams are personifications of our conception of people we know, e.g. having a stern, autocratic father might be portrayed by an army officer in the dream. Unfortunately, this idea based on C. G. Jung's theory of subjective level of dream interpretation has not been tested empirically, e.g., a man with such a stern father should dream more often of army officers or some other dominating male characters. The viewpoint of continuity of waking and dreaming is especially interesting when looking at Freud's dreams that he reported in his book "Die Traumdeutung" (Schredl, 2008a).

Yet, there might be other explanations for discontinuity, e.g. walking dreams in congenital paraplegics. As Hobson suggested that dreaming is a PREPLAY from early on (starting from birth or even before birth), one might speculate that there are topics that are hard-wired and genetically encoded experiences (Hobson & Schredl, 2011). In terms of C. G. Jung, this could be understood as contents of the collective unconscious (Hoss, 2011). That there might be innate dream images makes sense but research in this area, for example, looking at dreams of amputees whether they have intact bodies in their dreams is far from conclusive (Brugger, 2008). Another explanation that should not be overlooked was put forward by Schredl (2012) who analyzed pain dreams in a long dream series. About 20% of the pain dreams included pain experiences the dreamer never experienced in his life. As pain can be perceived while watching a person in pain, one might hypothesize that information processing done by mirror neurons in the waking state might explain discontinuous dream elements. Within this context, the effect of media (Van den Bulck, 2004) or videogame playing (Gackenbach, Sample, & Mandel, 2011) on dreaming should also not be overlooked.

To sum up this section, the study of discontinuity – in my opinion – will be very beneficial for the understanding of dreams.

Functions of dreaming

Blagrove (2011) and Domhoff (2011) pointed out that dreaming might be psychologically meaningful and even serve cultural functions but that this does not imply that dreaming is adaptive. Nevertheless, people and researchers alike were fascinated by the question as to what functions dreams might have. Some of the proposed functions of dreaming are listed in Table 2.

Flanagan (2000a) promoted the idea that dreams are a pure epiphenomenon of sleep, especially REM sleep, and did not add anything to the well-documented functions of sleep and REM sleep, e.g., memory consolidation (Diekelmann, Wilhelm, & Born, 2009). Walker (2005) pointed out that memory consolidation might happen on a cellular level without any consciousness involved. Jouvet (1998) postulates that the function of REM sleep is to periodically reinforce genetic programs to restore our individuality and diversity within our species, despite a changing environment. This theory – even though not referred to – seems to be

Table 2: Possible functions of dreaming

Theories	Author(s)
• Dreams as epiphenomenon	Flanagan (2000b)
• Iterative Programming	Jouvet (1998)
• Guardian of Sleep	Freud (1987/1900)
• Compensation	Jung (1979)
• Reverse learning hypothesis	Crick and Mitchison (1983)
• Mastery hypothesis	Wright and Koulack (1987)
• Mood regulation	Kramer (2007), Cartwright (2010)
• Systematic desensitization	Perlis and Nielsen (1993)
• Threat simulation theory	Revonsuo (2000)
• Memory consolidation	Wamsley and Stickgold (2010), Hartmann (2011b)
• Protoconsciousness theory	Hobson (2009)

a precursor of Hobson's protoconsciousness theory, postulating that the development and maintenance of waking consciousness depends on brain activation and dreaming during sleep (Hobson, 2009). Freud (1987/1900) saw dreams as the guardian of sleep because they allow the catharsis of unconscious id impulses which would have awakened the sleeper otherwise. Based on C. G. Jung's Analytical Psychology, the dream serves as compensatory mechanism for the single-minded waking consciousness, i.e., dreams enhance individuation – a theory which was discussed in the commentary of Hoss (2011).

The reverse learning theory (Crick & Mitchison, 1983), the mood regulation theory (Kramer, 2007), the mastery hypothesis (Wright & Koulack, 1987), systematic desensitization (Perlis & Nielsen, 1993), and the memory consolidation theory (Wamsley & Stickgold, 2010) implicate that dreaming is helpful in learning important things or forgetting unnecessary information. In their commentary, Horton and Malinowski (2011) focused on the function of dreaming in memory consolidation as the most plausible one.

While reviewing these theories regarding dream function, it is very crucial to differentiate between the physiological level (REM sleep) and the psychological level (dreaming). I.e., physiological processes in REM sleep (and NREM sleep) that are involved in sleep-dependent memory consolidation might not be at all related to dreaming (Schredl & Erlacher, 2010). Blagrove (2011) pointed out that studying possible functions of dreaming is difficult because dream content cannot manipulated experimentally. I.e., the finding of Wamsley, Tucker, Payne, Benavides, and Stickgold (2010) that dreams of the task remembered after a brief nap were related to increased performance after the nap could be seen as an effect of the dream or alternatively, the dream and the increase in performance were cause by a third, yet unknown factor. I.e., dreaming is just an indicator not the cause. Another problem is illustrated by using the study of Cartwright, Lloyd, Knight, and Trenholm (1984). They found that divorcing women dreaming about their ex-husband are more psychologically adapted after one year than women who dreamed about other topics. The authors concluded that working through the divorce issue within in the dream serves an adaptive function. But one might argue that the women who reported the ex-husband dreams began to think about these dreams and, therefore, were able to cope better with the stressful divorce. From this viewpoint, the yet unsolvable problem is that one cannot differentiate between the effect of the dreamed dream and the effect of the recalled, reported dream (necessarily processed by the waking mind), i.e., we do not know and might never know whether unremembered dreams serve any function.

To summarize, dreaming might serve one or more function(s) but due to immanent methodological issues we still do not know whether dreaming defined as subjective experiencing while sleeping has a beneficial effect itself. As stated above, this does not implicate that dreams are not helpful, for example, regarding creativity, self-actualization, or psychotherapy. .

How to study continuity and/or discontinuity between waking and dreaming?

For studying the continuity and/or discontinuity between waking and dreaming, all three aspects have to be assessed in a psychometrically reliable and valid manner: waking life, dreaming, and the linking between waking life and dream content. Let me start with measuring dream content. The method of dream collection (most recent dreams, diary dreams, dreams obtained from laboratory awakenings) might have a strong effect on the result of continuity studies as there might be biases due to retrospective recall or the effect of the experimental setting on dreams (Schredl, 2010b). Measuring dream content was refined by Calvin Hall and Robert Van de Castle (1966) and others (Schredl, 2010a). These rating systems allow quantification of dream features reliably, even though some issues regarding validity has not been resolved completely. Schredl and Doll (1998), for example, found that dream emotions were underrated by external judges looking at the dream reports compared to the dreamer's own estimation of his/her emotions within the dream. Similarly, the number of bizarre elements was lower

if judges did the scoring compared to the dreamer himself/herself (Schredl & Erlacher, 2003). This indicates that dream reports needed to be complemented with probing for specific contents, e.g., meta-cognition (Kahan & LaBerge, 1996) or emotions (Merritt, Stickgold, Pace-Schott, Williams, & Hobson, 1994). Gackenbach et al. (2011) pointed out in their commentary that the Hall and Van de Castle rating systems might be problematic for analyzing dreams of high-end gamers because the virtual reality scenarios of their video games within the dream cannot be coded properly. Nevertheless, the measuring of dream content is very sophisticated. On the other hand, measuring the other "side of the coin" (waking life) seems more problematic. For example, how does a researcher measure reliably current concerns of the participants? Malinowski and Horton (2011) used a diary approach where the persons were asked to write down the most important events and experiences of the day in the evening. One has to keep in mind that reflecting on the day and keeping a journal might have an effect on dreaming, so Schredl and Hofmann (2003) used a retrospective questionnaire for measuring daytime activities given to the participants after keeping a dream diary over two weeks. This approach suffers from possible recall problems, i.e., how good are the participants in recalling their activities after two weeks but does not have the problem that the measurement of daytime activities affects the participants' dreams. Similarly, Domhoff (2003) used interviews in which the dreamers were asked about their preoccupations in waking life. A totally different approach was adopted by Strauch (2004); she compared waking fantasy reports with dreaming. As Hartmann (2011a) pointed out, the differences between waking cognitive activity and dreaming regarding formal characteristics depend very strongly on the sampling of the waking reports (daydreams, diary entries, interviews etc.). This problem has been emphasized in previous research (Foulkes & Fleisher, 1975).

The last methodological issue in this context is the measuring of correspondences between waking and dreaming. Very different approaches have been applied. Bulkeley and Domhoff (2010), for example, analyzed long dream series in order to make predictions about the concerns, conceptions, and preoccupations of the dreamer and asked the dreamer whether these predictions are correct. External judges were used in the study of Roussy et al. (2000) comparing dream reports with descriptions of day-time events. One might imagine that matching dream reports to the waking life of the dreamer might be very difficult for external judges because they know so little about the dreamer. Therefore, it

seems to make sense to ask the dreamer himself/herself to link dream elements to waking life – as done in the studies of Schredl (2006), Blagrove, Henley-Einion, Barnett, Edwards, and Seage (2011), and Malinowski and Horton (2011). These results were much more promising than the studies using external judges, so this methodological issue should be looked at very carefully. The procedure of matching can even be intensified by carrying out dreamwork sessions with the dreamer to help him/her to find correspondences between waking life and dreaming (Malinowski & Horton, 2011); an approach which seems very helpful in studying the continuity hypothesis.

As mentioned above, an issue that had not been addressed in a systematic way is the question as to what kind of correspondences should be considered. I.e., should the dream scene be an exact replay of the waking life experience? Is it still related to waking life if a dream stranger has the same personality characteristics as the dreamer's father? A clear definition is very important for the studies cited above in which the participants themselves were asked to match dream elements and waking life. Regarding this point, many more studies with different approaches are needed.

After pointing out some (not all – I think) methodological issues important in studying continuity between waking and dreaming, I would like to emphasize that there are various paradigms for studying and testing the continuity hypothesis (see Table 3). This compilation is by no means complete and many more approaches have been applied and will be applied. The purpose of reviewing some of the approaches is to illustrate that different approaches aim at different aspects of the continuity hypothesis.

The most detailed study looking at temporal references of dream elements were carried out by Strauch and Meier (1996). Fifty dreams stemming from REM awakenings of five subjects included 80 key role characters, 39 extras (person playing a minor role in the dream), 74 settings and 298 objects. The ability to relate these elements to waking life by the dreamer varied considerably: 25.6 % (extras), 30.9 % (objects) and 76.3 % (key role characters). I. e., the participants were able to find for 76.3 % of the key role characters correspondences to their waking life, e. g. they thought about this person or have encountered her/him. Even though this method seems straight-forward (and have also been used in the clinical setting), there are several problems: If one included waking thoughts, memory restrictions might be a major problem because no one can recall all the thoughts of the previous day, let alone of the previous week. Another problem is that multiple correspondences of dream elements might be frequent; if the person dreams about his mother this might correspond to a telephone conversation two days ago or to a childhood experience. This problem can only be avoided by studying novel and unique waking life experiences. Due to this problem, many researchers (including myself) do not think that the retrospective approach is very helpful in studying the continuity hypothesis quantitatively.

A very interesting approach called "blind" analysis has been developed by Hall (1947) and further pursued by Domhoff (2003) and others (Bulkeley & Domhoff, 2010). Dream series (the more dreams the better) are quantitatively analyzed by rating systems (Hall & Van de Castle, 1966) or word search algorithms (Bulkeley & Domhoff, 2010) and, then, the researchers derived predictions as to what should be promi-

Table 3: Paradigms for studying the relationship between waking and dreaming

Aspects
• Assessing temporal references of dream elements
• "Blind" analysis of dream series

• Diary studies
   - Within-subject approach
   - Between-subject approach

• Experimental manipulation of daytime experiences
• Lucid dreaming

nent in the dreamer's waking life. Analyzing the dream series of a woman, Domhoff (2003) found, for example, strong correspondences between the social interactions within the dream and the real-life social interactions with this person (mother, sister, brother, friends), i.e., if the relationship was full of conflicts in waking life, the aggressiveness/friendliness index for this dream character was high (much more aggressive interactions compared to friendly interactions). Although this approach is quite useful because dream features are measured precisely due to the large number of dreams (for a discussion see: Schredl, 1998), the major problem with this approach is that the matching between dream content and waking-life of the dreamer is rather vague, depending on data obtained through interviews carried out with the dreamer. If you look, for example, at the concerns of students, it seems plausible that various concerns (studying, friends, leaving home, etc.) are quite similar between students and, thus, correspondences between dream content and waking can be found even if the waking data were obtained from another student. I.e., to test this approach in a statistically sound way, it would be necessary to compare the predictions of the researcher to a larger set of interviews about the person's waking concerns (provided by different persons) and – hopefully – an above chance finding for the correct pair would be obtained.

A simple approach is using a diary in which the participants fill in daytime events and their dreams. In the study of Schredl and Reinhard (2009-2010), the participants were asked after each dream whether the dream has any correspondences with the previous day(s), whereas in the study of Blagrove, Henley-Einion, et al. (2011) the participants matched dreams and day reports after the two-week period in which they kept the diary. As mentioned above, systematic research in defining different kinds of correspondences (thematic, emotional, metaphorical) has not been carried out and is very much needed. Otherwise, the subjectivity of each participant doing the matches can heavily influence the findings. Whereas these studies looked at correspondences within each participant, the diary method can also be used for testing whether interindividual differences in waking life are reflected in corresponding differences in dreaming. Schredl and Hofmann (2003), for example, correlated the amount of time spent with specific activities during the day with the frequency of these activities in dreams; persons who drove quite often in their waking life also had driving dreams more often. As stated above, the diary approach has the problem that recording daytime experience (and dreams) can affect subsequent dreams and, therefore, can bias the results of this kind of study. A major issue, of course, is how detailed the waking life is measured and are only major events of the day or more detailed descriptions of the day included. It seems impossible to record all experiences, feelings, events, thoughts of even one day in order to compare such detailed protocols to subsequent dreams.

Another option is to study the effect of experimental manipulation of waking-life experiences on dreams. De Koninck and Brunette (1991), for example, exposed phobic participants to a snake (in a terrarium) and read them different stories prior to sleep onset. Interestingly, the emotional tone of the story affected the participants' dream emotions but not the dream content. The problem of manipulating dream content by pre-sleep films was often found (cf. Schredl, 2008d); real-life stress often showed much stronger effects on dreaming (Breger, Hunter, & Lane, 1971). A very interesting paradigm for studying the continuity between waking and dreaming has been somewhat neglected because these studies focused on methodological issues: studying the references to the experimental setting in dreams obtained by REM or NREM awakenings in the sleep laboratory (Schredl, 2008b). Lab references can be found quite often in dreams (about 20% in over 2.000 dreams collected in 12 studies) and, thus, clearly demonstrate continuity. The review suggested that emotional factors, e.g., worries about the EEG technology, might be an explanation of higher incorporation rates in earlier studies when sleep laboratories were not well known in the general public as it is in our day (Schredl, 2008b); however, this hypothesis was not studied systematically.

The last paradigm included in this brief review, is lucid dreaming. Proficient lucid dreamers can carry out specific tasks in their dreams (LaBerge, 1985); this remembering of the instructions given by the experimenter while awake clearly indicates continuity between waking and dreaming. As they can also carry out pre-arranged eye signals in the dreams which can be measured by electrooculogram in the sleep laboratory, these types of dream reports can be verified (Erlacher & Schredl, 2008). Interestingly, lucid dreaming might help to study the function of dreaming because Erlacher and Schredl (2010) found that practicing a simple motor task within a lucid dream enhances daytime performance.

Lastly, I would like to emphasize the fact that studying special populations might help to study the continuity between waking and dreaming. Hartmann (1998), for example, pointed out that studying persons suffering from trauma might be very promising because in these persons their waking-life concern (experiences, emotions, etc.) is easily assessed. However, other researchers (e.g., Kramer, 1991) hypothesized that nightmares and specifically posttraumatic re-enactments are a failure of normal dream function and, thus, the generalizability of findings in trauma patients is limited. Other very interesting groups are paraplegics (Saurat et al., 2011), amputees (Mulder, Hochstenbach, Dijkstra, & Geertzen, 2008), mute-deaf persons (Voss, Tuin, Schermelleh-Engel, & Hobson, 2011) because their waking life differs in particular aspects compared to that of unaffected persons, especially if the handicap is congenital. Even though dreams of blind persons have been studied quite intensely, systematic research in linking their waking life experiences to their dream content is still lacking; the major focus was on the differences between the dreams of blind persons compared to those of seeing persons (Lopes de Silva, 2003). Another group which has been studied are patients with brain damage in order to test whether specific cognitive deficits found in the waking state are reflected in alterations of dream recall and dream content (Murri et al., 1989). Studying the relationship between psychopathology and dream content in psychiatric patients (Schredl & Engelhardt, 2001) also yielded promising results. As the findings of Gackenbach et al. (2011) indicate, very intense engagement in specific waking activities like gaming can exhibit a very strong effect on dreaming. This list shows that interesting studies can be carried out in very different populations and as this list is far from being exhaustive. I would like to encourage all fellow researchers to study the dreams of populations with very specific alterations of their waking-life experience.

Conclusions

Even though the question about possible functions of dreams is the most interesting one, I believe that much research is needed before this enigma can be solved. As dream research is a small field, it is necessary that researchers discuss their theories openly and replicate each other's findings, applying different methodological approaches for studying the same phenomena.

References

Blagrove, M. (2011). Distinguishing continuity/discontinuity, function and insight when investigating dream content. International Journal of Dream Research, 4, 45-47.

Blagrove, M., Fouquet, N. C., Henley-Einion, J. A., Pace-Schott, E. F., Davies, A. C., Neuschaffer, J. L., & Turnbull, O. H. (2011). Assessing the Dream-Lag Effect for REM and NREM Stage 2 Dreams. PLoS ONE, 6(10), e26708. doi: 10.1371/journal.pone.0026708

Blagrove, M., Henley-Einion, J., Barnett, A., Edwards, D., & Seage, C. H. (2011). A replication of the 5-7 day dream-lag effect with comparison of dreams to future events as control for baseline matching. Consciousness and Cognition, 20(2), 384-391. doi: 10.1016/j.concog.2010.07.006

Breger, L., Hunter, I., & Lane, R. W. (1971). The effect of stress on dreams. New York: International Universities Press.

Brugger, P. (2008). The phantom limb in dreams. Consciousness and Cognition: An International Journal, 17(4), 1272-1278.

Bulkeley, K. (2011). Testing the Continuity Hypothesis. International Journal of Dream Research, 4, 48-49.

Bulkeley, K., & Domhoff, G. W. (2010). Detecting meaning in dream reports: An extension of a word search approach. Dreaming, 20, 77-95.

Cartwright, R. D. (2010). The twenty-four hour mind: The role of sleep and dreaming in our emotional lives. New York, NY US: Oxford University Press.

Cartwright, R. D., Bernick, N., Borowitz, G., & Kling, A. (1969). Effect of an erotic on the sleep and dreams of young men. Archives of General Psychiatry, 20, 262-271.

Cartwright, R. D., Lloyd, S., Knight, S., & Trenholm, I. (1984). Broken dreams: a study of the effects of divorce and depression on dream content. Psychiatry, 47, 251-259.

Crick, F., & Mitchison, G. (1983). The function of dream sleep. Nature, 304, 111-114.

De Koninck, J., & Brunette, R. (1991). Presleep suggestion related to a phobic object: successful manipulation of reported dream affect. Journal of General Psychology, 118, 185-200.

Diekelmann, S., Wilhelm, I., & Born, J. (2009). The whats and whens of sleep-dependent memory consolidation. Sleep Medicine Reviews, 13, 309-321.

Domhoff, G. W. (2003). The scientific study of dreams: neural networks, cognitive development and content analysis. Washington: American Psychological Association.

Domhoff, G. W. (2011). Dreams Are Embodied Simulations That Dramatize Conception and Concerns: The Continuity Hypothesis in Empirical, Theoretical, and Historical Context. International Journal of Dream Research, 4, ´50-62.

Erlacher, D., & Schredl, M. (2004). Dreams reflecting waking sport activities: a comparison of sport and psychology students. International Journal of Sport Psychology, 35, 301-308.

Erlacher, D., & Schredl, M. (2008). Do REM (lucid) dreamed and executed actions share the same neural substrate? International Journal of Dream Research, 1, 7-14.

Erlacher, D., & Schredl, M. (2010). Practicing a motor task in a lucid dream enhances subsequent performance: A pilot study. Sport Psychologist, 24, 157-167.

Flanagan, O. (2000a). Dreaming is not an adaption. Behavioral and Brain Sciences, 23, 936-939.

Flanagan, O. (2000b). Dreaming souls: sleep, dreams, and the evolution of the conscious mind. Oxford: Oxford University Press.

Foulkes, D., & Fleisher, S. (1975). Mental activity in relaxed wakefulness. Journal of Abnormal Psychology, 84, 66-75.

Freud, S. (1987). Die Traumdeutung (1900). Frankfurt: Fischer Taschenbuch.

Gackenbach, J. I., Sample, T., & Mandel, G. (2011). The Continuity versus Discontinuity Hypotheses: A Consideration of Issues for Coding Video Game Incorporation. International Journal of Dream Research, 4.

Hall, C. S. (1947). Diagnosting personality by the analysis of dreams. Journal of Abnormal and Social Psychology, 42, 68-79.

Hall, C. S. (1951). What people dream about? Scientific American, 184(5), 60-63.

Hall, C. S. (1953). The cognitive theory of dreams. Journal of General Psychology, 49, 273-282.

Hall, C. S., & Nordby, V. J. (1972). The individual and his dreams. New York: New American Library.

Hall, C. S., & Van de Castle, R. L. (1966). The content analysis of dreams. New York: Appleton-Century-Crofts.

Hartmann, E. (1998). Nightmare after trauma as paradigm for all dreams: a new approach to the nature and functions of dreaming. Psychiatry, 61, 223-238.

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

Hartmann, E. (2011a). Continuity? Yes, Emotional Continuity. International Journal of Dream Research, 4.

Hartmann, E. (2011b). The nature and functions of dreaming. New York: Oxford University Press.

Hobson, J. A. (2009). REM sleep and dreaming: towards a theory of protoconsciousness. Nature Reviews Neuroscience, 10(11), 803-813.

Hobson, J. A., Pace-Schott, E. F., & Stickgold, R. (2000). Dreaming and the brain: toward a cognitive neuroscience of conscious states. Behavioral and Brain Sciences, 23, 793-842.

Hobson, J. A., & Schredl, M. (2011). The continuity and discontinuity between waking and dreaming: A Dialogue between Michael Schredl and Allan Hobson concerning the adequacy and completeness of these notions. International Journal of Dream Research, 4, 3-7.

Horton, C. L., & Malinowski, J. E. (2011). Re-defining discontinuity: Implications for the functions of dreaming. International Journal of Dream Research, 4, 78-80.

Hoss, B. (2011). The continuity and discontinuity between waking and dreaming from the perspective of an analytical psychological construct. International Journal of Dream Research, 4, 81-83.

Jouvet, M. (1998). Paradoxical sleep as a programming system. Journal of Sleep Research Supplement, 7(1), 1-5.

Jung, C. G. (1979). Allgemeine Gesichtspunkte zur Psychologie des Traumes. In C. G. Jung (Ed.), Gesammelte Werke Band 8: Die Dynamik des Unbewußten (pp. 268-308). Olten: Walter.

Kahan, T. L., & LaBerge, S. (1996). Cognition and metacognition in dreaming and waking: comparisons of first and third-person ratings. Dreaming, 6, 235-249.

Kahn, D. (2011). The Synthesis of Dream Sources. International Journal of Dream Research, 4, 84-85.

Kramer, M. (1991). The nightmare: a failure in dream function. Dreaming, 1, 277-285.

Kramer, M. (2007). The dream experience: a systematic exploration. New York: Routledge.

LaBerge, S. P. (1985). Lucid dreaming. Los Angeles: Jeremy P. Tarcher.

Lopes de Silva, F. H. (2003). Visual dreams in the congenitally blind? Trends in Cognitive Sciences, 7, 328-330.

Malinowski, J., & Horton, C. L. (2011). Themes of Continuity. International Journal of Dream Research, 4, 86-92.

Meier, B. (1993). Speech and thinking in dream. In C. Cavallero & D. Foulkes (Eds.), Dreaming as cognition (pp. 58-76). London: Harvester Wheatsheaf.

Merritt, J. M., Stickgold, R., Pace-Schott, E., Williams, J., & Hobson, J. A. (1994). Emotion profiles in the dreams of men and women. Consciousness and Cognition, 3, 46-60.

Mulder, T., Hochstenbach, J., Dijkstra, P. U., & Geertzen, J. H. B. (2008). Born to adapt, but not in your dreams. Consciousness and Cognition: An International Journal, 17(4), 1266-1271.

Murri, L., Mancino, M., Massetani, C., Canapicchi, R., Puglioli, M., & G., R. (1989). Effects of acute and chronic brain damage on dreaming. Research Communications in Psychology, Psychiatry and Behavior, 14, 121-142.

Perlis, M. L., & Nielsen, T. A. (1993). Mood regulation, dreaming and nightmares: evaluation of a desensitization function for REM sleep. Dreaming, 3, 243-257.

Reed, H. (1978). Meditation and lucid dreaming: a statistical relationship. Sundance Community Dream Journal, 2, 237-238.

Revonsuo, A. (2000). The reinterpretation of dreams: an evolutionary hypothesis of the function of dreaming. Behavioral and Brain Sciences, 23, 877-901.

Roussy, F., Brunette, M., Merier, P., Gonthier, I., Grenier, J., Sirois-Berliss, M., . . . De Koninck, J. (2000). Daily events and dream content: unsuccessful matching attempts. Dreaming, 10, 77-83.

Saurat, M.-T., Agbakou, M., Attigui, P., Golmard, J.-L., & Arnulf, I. (2011). Walking dreams in congenital and acquired paraplegia. Consciousness and Cognition, 20(4), 1425-1432. doi: 10.1016/j.concog.2011.05.015

Schredl, M. (1998). The stability and variability of dream content. Perceptual and Motor Skills, 86, 733-734.

Schredl, M. (2003). Continuity between waking and dreaming: a proposal for a mathematical model. Sleep and Hypnosis, 5, 38-52.

Schredl, M. (2006). Factors affecting the continuity between waking and dreaming: emotional intensity and emotional tone of the waking-life event. Sleep and Hypnosis, 8, 1-5.

Schredl, M. (2008a). Freud's interpretation of his own dreams in "The interpretation of dreams": a continuity hypothesis perspective. International Journal of Dream Research, 1, 44-47.

Schredl, M. (2008b). Laboratory references in dreams: Methodological problem and/or evidence for the continuity hypothesis of dreaming? International Journal of Dream Research, 1, 3-6.

Schredl, M. (2008c). Personality correlates of flying dreams. Imagination, Cognition and Personality, 27, 129-137.

Schredl, M. (2008d). Traum. München: Reinhardt/UTB.

Schredl, M. (2010a). Dream content analysis: Basic principles. International Journal of Dream Research, 3, 65-73.

Schredl, M. (2010b). Dreams. In J. W. Winkelman & D. T. Plante (Eds.), Foundations of psychiatric sleep medicine (pp. 79-93). Cambridge: Cambridge University Press.

Schredl, M. (2011). Frequency and nature of flying dreams in a long dream series. International Journal of Dream Research, 4, 31-34.

Schredl, M. (2012). Frequency and nature of pain in a long dream series. Sleep and Hypnosis, submitted.

Schredl, M., Desch, S., Röming, F., & Spachmann, A. (2009). Erotic dreams and their relationship to waking-life sexuality. Sexologies, 18, 38-43.

Schredl, M., & Doll, E. (1998). Emotions in diary dreams. Consciousness and Cognition, 7, 634-646.

Schredl, M., & Engelhardt, H. (2001). Dreaming and psychopathology: dream recall and dream content of psychiatric inpatients. Sleep and Hypnosis, 3, 44-54.

Schredl, M., & Erlacher, D. (2003). The problem of dream content analysis validity as shown by a bizarreness scale. Sleep and Hypnosis, 5, 129-135.

Schredl, M., & Erlacher, D. (2007). Self-reported effects of dreams on waking-life creativity: An empirical study. Journal of Psychology, 141, 35-46.

Schredl, M., & Erlacher, D. (2008). Relationship between waking sport activities, reading and dream content in sport and psychology students. Journal of Psychology, 142, 267-275.

Schredl, M., & Erlacher, D. (2010). Is sleep-dependent memory consolidation of a visuo-motor task related to dream content? International Journal of Dream Research, 3, 74-79.

Schredl, M., & Hofmann, F. (2003). Continuity between waking activities and dream activities. Consciousness and Cognition, 12, 298-308.

Schredl, M., & Reinhard, I. (2009-2010). The continuity between waking mood and dream emotions: Direct and second-order effects. Imagination, Cognition and Personality, 29, 271-282.

Strauch, I. (2004). Träume im Übergang von der Kindheit ins Jugendalter: Ergebnisse einer Langzeitstudie. Bern: Hans Huber.

Strauch, I., & Meier, B. (1996). In search of dreams: results of experimental dream research. Albany: State University of New York Press.

Stumbrys, T. (2011). Lucid dreaming: discontinuity or continuity in consciousness? International Journal of Dream Research, 4, 93-97.

Van den Bulck, J. (2004). Media use and dreaming: the relationship among television viewing, computer game play, and nightmares or pleasant dreams. Dreaming, 14, 43-49.

Voss, U., Tuin, I., Schermelleh-Engel, K., & Hobson, J. A. (2011). Waking and dreaming: Related but structurally independent. Dream reports of congenitally paraplegic and deaf-mute persons. Consciousness and Cognition, 20(3), 673-687. doi: 10.1016/j.concog.2010.10.020

Walker, M. P. (2005). A refined model of sleep and the time course of memory formation. Behavioral and Brain Sciences, 28, 51-64.

Wamsley, E. J., & Stickgold, R. (2010). Dreaming and offline memory processing. Current Biology, 20, R1010-R1013.

Wamsley, E. J., Tucker, M., Payne, J. D., Benavides, J. A., & Stickgold, R. (2010). Dreaming of a learning task is associated with enhanced sleep-dependent memory consolidation. Current Biology, 20, 850-855.

Wright, J., & Koulack, D. (1987). Dreams and contemporary stress: a disruption-avoidance-adaptation model. Sleep, 10, 172-179.