

# **The Influence of External Stimuli on the Frequency and Quality of Lucid Dreams**

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# 1 Introduction

Most of us would like to change the world around us. Most of us live their lives and think about how much better everything would be if that or this would be according to our wishes. Some dream about having divine power. However, most of us do not know that we already have such power, that we do not have to dream about it, that it is dreams that give us the possibility to create our own perfect world. Everybody is familiar with the feeling of waking up and surprisingly realizing that the dream was not reality. It does not matter whether a zombie is hunting us or we find ourselves on the moon without any oxygen, we are completely certain that we are awake and everything is real. We are therefore capable of creating a convincing world, which feels incredibly real, even more real than reality, a state of hyperreality. However, everybody who experienced nightmares will agree, that this world is not the world we would necessarily want to live in, since we do not consciously choose what we dream about. The solution to this problem is easy: we just have to know that we dream. When we are consciously aware of the fact that we dream, we can alter the dream in any way we want and do whatever we can imagine, since we are the ones who create the dream world in the first place. In a sense we already have the perfect virtual reality machine through our dreams. Every human can create a world to fulfill his wishes, to solve problem and to research his own subconsciousness. The practical application of this process is, however, more troublesome than the theory. I hope to make lucid dreaming induction (recognizing the dream as such), stabilization, and control easier through technology. Therefore I developed a lucid dreaming induction device called “Extreme Lucidity” (ExLu). In the following paper I will present my research on how lucid dreams can be stimulated through visual and acoustic clues and whether those stimuli increase the likelihood of becoming lucid and how they affect the dream content. First I will explain what lucid dreams are, then I will present the technical details and functions of “Extreme Lucidity”, then my experiments and discuss, whether Neurofeedback could aid ExLu.

## 2 Lucid dreams

### 2.1 Definition

Lucid dreams are dreams in which we know that we are dreaming. Every dream can only be regarded as lucid, when this criteria is met. However, there is no unified definition and some scientists argue that there are more criteria when we want to define a dream as lucid. Paul Tholey e.g. talks about following criteria:

1. The dreamer is fully aware that he dreams.
2. The conscious state of the dreamer is not restricted.
3. All senses have the full functionality as in the awake world.
4. The dreamer has full memories of the awake world.
5. Awake as in the lucid dream, the dreamer must remember the previous events of the lucid dream.[2]

These criteria are not applied in this paper when I talk about lucid dreams, since many see them as too strict. E.g the functionality of the senses or memory of the lucid dream are not necessarily given, especially for beginners, because lucid dreams are oft instable, which also can affect the perception in the dream like a blurred view. When those things occur, but the dreamer still knew that he was dreaming, during the dream, we can still call it a lucid dream.

### 2.2 Frequency of Lucid Dreams

Before I present the most popular induction methods, we should first ask ourselves, why we do not dream lucid all the time. Why do the most of us not know that we dream, even though so many strange and weird things happen, which during the dream seem normal, but as soon as we awake we wonder how we could confuse the dream with reality. On the other hand, maybe we are mistaken and everybody is already a lucid dreamer?

Many studies about the frequency of lucid dreams exist, but the results vary immensely. Probably the most popular result is, that a quarter of all humans had a lucid dream (Stepansky et al., 1998). Other studies even found out frequencies of 100% (Snyder und Gackenbach 1988). The varying results are due to different groups questioned. Students and people, who are interested in parapsychology are reporting more lucid dreams as those who do not. Furthermore it is important, whether the study group even knows what lucid dreams are. Some studies do not mention the definition of lucid dreams. Snyder and Gackenbach found out that in a study 707 students reported that they had lucid dreams, but 344 reports are questionable, since it seemed that the dreams reported do not show signs of lucidity. When we eliminate all those errors, Snyder and Gackenbach report that 57.5 of all humans had a lucid dream.[4]

Even more difficult is the determination how often an individual dreams lucid. It could be possible, that we dream more often lucid, but we don't remember, since the majority has problems with dream recall. On the other hand lucid dreams tend to be remembered really well and those who train to become lucid also train dream recall. Therefore I am skeptical whether forgotten lucid dreams have a significant impact on such studies.

### 2.3 Dream and Awake World

We can conclude, that lucid dreams are not a completely unknown phenomenon for most people, even though the least ever heard about it. Nevertheless lucid dreams are an exception for us. We spend most of our dream time (about 4 years in a human life) without knowing that we dream.

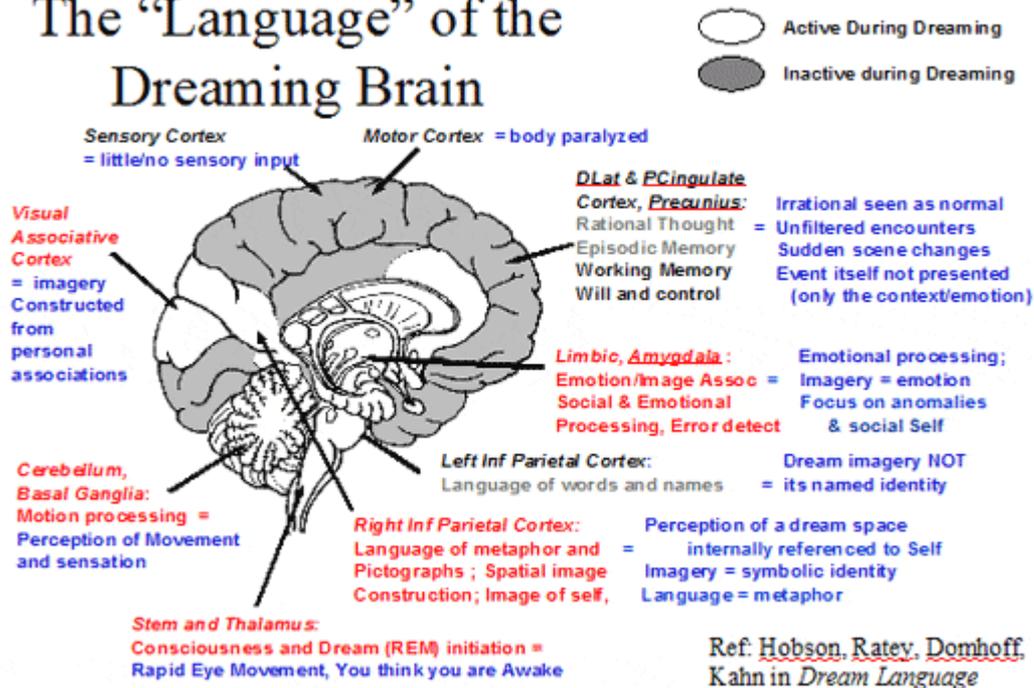
Is it however not paradoxical? Dreams are so weird, so obviously unreal, that it should not be possible to confuse dreaming with being awake. Why do we never ask ourselves when a Monster is standing in front of us: "Can this be real? Do I maybe dream?" That sounds plausible, but on the other hand, how many times a day do we ask ourself whether we are awake or dreaming? Most of us never ask this question. Is our brain not capable of differentiating whether we are awake or asleep? LaBerge compared how actions and perception differ in dreams and when we are awake. The result was, that there are only few differences, whether we move our eyes in our dreams or while awake, whether we sing or whether we see something, because the same activity in visual areas of our brain were recorded. Our brain constructs the world, based on information, which we acquire through our senses. When we dream, we perceive the exact same construct, only the cause is different. When we dream about an apple, it does not matter, whether the apple is real for our perception. We believe seeing the same apple, whether it is a real one or a dreamed one, because our brain created the same information about the apple.[1]

Our problem of confusing the two worlds is additionally increased by the restricted cognitive thinking and causal-logic memory in dreams compared to our abilities while awake. The reason is the altered brain activity during our sleep, which cause a lack of rationality and an increase of the importance of emotions. PET (Positron-Emission-Tomography) studies showed, that two brain areas are especially active during REM: the limbic and paralimbic system, which contain the amygdala, hippocampus, the parahippocampal cortex, the anterior cingulate cortex, and medial prefrontal cortex. All those brain areas are responsible for emotional behavior and its physiological realization. That is why dreams often unleash strong feelings and we behave very emotional during them. This seems to be the case in lucid dreams, too. I sometimes do not do in lucid dreams what I planned when I was awake, because I get distracted by other things, and then when I wake up, I ask myself why I did that. In the dream it seemed like the right thing to do.

Also active is the right hypothalamus, which regulates the sensory, emotional, and cognitive functions of the body. A lot more interesting, however, is the connection between the frontal cortex and the areas of the brain responsible for perception. The frontal cortex has an immense influence on cognitive abilities. Especially important is the prefrontal cortex, part of the frontal cortex. It is responsible for the evaluation of sensory input, which are forwarded from the perception areas, connects them with emotions and memories, and initiates based on those our behavior. During our dreams the exchange of information between the frontal cortex and the perception areas does not take place. This leads to a missing reality check, because the frontal cortex, which normally would recognize that what we perceive cannot be real, never gets the information what we perceive. That is why we think that dream is reality and our behavior is rather based on emotions rather than on logic.[5]

The following image summarizes how the brain areas responsible for rational thinking are inactive, like the Dlat and Pcingulate Cortex and the Precunius, contrary to the active emotional and visual areas.[5]

# The "Language" of the Dreaming Brain



pic. 1: The dreaming brain

An additional reason for the lack of critical thinking are the missing possibilities to compare reality and dream. When we see a science-fiction movie we realize that it is just fiction, because we have a direct comparison to reality. In dreams we do not have such direct comparisons, because we are to a large extent cut of reality and the dream is all there is, it is the only world we perceive and therefore counterfactual thinking is limited. [3]

## 2.4 Induction Methods

It is, however, not impossible to recognize the dream as such. Actually anyone can learn to dream lucid when someone is patient, persistent and disciplined, because unfortunately there is no ultimate easy one size fits all way to become lucid. A variety of induction techniques exist, but their effectiveness varies dramatically from person to person. One thing is certain, however: everybody who wishes to learn to dream lucid must remember his dreams. A good dream recall increases the likelihood of success immensely. How should one recognize that he is dreaming, when he does not even know what he dreams about? Besides getting a feeling how your dreams look and feel like it reduces the already mentioned possibility to forget a lucid dream.

We can categorize most techniques into DILD and WILD. DILD stand for „Dream-Induced Lucid Dream“. As the name suggests this technique aims at recognizing the dreams as such during the dream. A simple type is autosuggestion. We can tell ourself when we go to sleep: “I will dream lucid“. More effective is the popular MILD Technique. MILD is the abbreviation for „Mnemonic Induction of Lucid Dreams“. Mnemonic is already hinting, that this technique is about remembering that you dream. As already explained, this is hard, but memory aids, like dream signs, can help. The dreamer must train himself to associate events which are typical for dreams with the intention to recognize the dream as such.[1,4,8] LaBerge sums the technique he himself developed up with the following steps:

#### “1. Set up dream recall

Before going to bed resolve to wake up and recall dreams during each dream period throughout the night (or the first dream period after dawn, or after 6 a. m. or whenever you find convenient).

#### 2. Recall your dream

When you awaken from a dream period, no matter what time it is, try to recall as many details as possible from your dream. If you find yourself so drowsy that you are drifting back to sleep, do something to arouse yourself.

#### 3. Focus your intent

While returning to sleep, concentrate singlemindedly on your intention to remember to recognize that you're dreaming. Tell yourself: “Next time I'm dreaming, I want to remember I'm dreaming.” Really try to feel that you mean it. Narrow your thoughts to this idea alone. If you find yourself thinking about anything else, just let go of these thoughts and bring your mind back to your intention to remember.

#### 4. See yourself becoming lucid

At the same time, imagine that you are back in the dream from which you have just awakened, but this time you recognize that it is a dream. Find a dreamsign in the experience; when you see it say to yourself: “I'm dreaming!” and continue your fantasy. For example, you might decide that when you are lucid you want to fly. In that case, imagine yourself taking off and flying as soon as you come to the point in your fantasy that you “realize” you are dreaming.

#### 5. Repeat

Repeat Steps 3 and 4 until your intention is set, then let yourself fall asleep. If, while falling asleep, you find yourself thinking of anything else, repeat the procedure so that the last thing in your mind before falling asleep is your intention to remember to recognize the next time you are dreaming”

([4], p. 41)

Tooley suggest in his critical reflection technique to ask one self multiple times during the day, especially when dream signs occur, whether he is awake or dreaming. If we develop a critical consciousness in the awake world and it becomes a habit to ask the question whether we dream or not when strange events take place, then it will also become a habit to be critical in our dreams. [1,2,4] RC (Reality Check) can assist answering the question whether we dream or not. The most popular tests are the hand RC and the nose RC. If we look at our hands and count how many fingers we have, we would have either problems counting, since cognitive abilities are limited or we see suddenly more or less than five fingers when we are dreaming.[8] It is important to note that the reliability of such test varies greatly dependent from the individual and the situation. I personally have never reached an accurate result with the hand RC. Until now I have always counted five fingers, both in dreams and awake, but the nose RC gave almost always accurate results. The nose RC consists of closing the nose and trying to breathe. If it is possible, we are dreaming. This RC did not work for (I could not breath through a closed nose in a dream) only two times, so its success rate is over 99% for me. The reasons why RC fail are not completely clear. Some argue that RC

only work because of the placebo effect. If you believe that you can breath through your nose, you will be able to and since the dream content is to a very large extent influenced by the expectations of the dreamer, this explanation seems plausible. On the other hand did I have success with the Nose RC various times with negative expectations, since I was completely sure that I am not dreaming, and therefore was sure that I could not breath through the closed nose. Furthermore lucid dream reports from forum.klartraum.de suggest that RCs are to a large extent universal and therefore I assume that there is a tendency for many people's brains not being able to replicate those events accurately as in the awake world.

A completely different approach to achieve lucidity exists, too. I explained how we can become lucid during a dream, but it is also possible to enter a lucid dream directly by falling asleep consciously. The aim is to stay conscious, but loosing wakefulness, so that your body falls into sleep, but your mind does not and you therefore dream lucid. This is called WILD (Wake-Initiated Lucid Dreams). This is achieved e.g. by counting and thinking "I dream" between the dreams. Tholey and LaBerge also suggest to concentrate on hypnagogic imagery, hallicunations which occur during sleep onset. The person seems to be awake, but brainwaves indicate that she is already asleep.[8] The advantage is, that during such hallucinations we are aware of our state, we know that hypnagogic imagery are strong visual conceptions. When the dreamer concentrates on them, he can slip into a dream, without loosing the awareness if his own state and therefore the dreamer still knows that everything is fiction, with the difference, that he is now dreaming.[1,2,4,8] Those are just a few examples of how we can retain conscious during falling into sleep. It is especially for WILD critical to apply the techniques when you would have normally a REM phase, since you want to directly enter a dream. It is therefore obvious that the success is increased when we try it when we normally would have a dream, too. Practicing DILD Techniques before an REM is also beneficial and therefore many lucid dreamers wake up after five hours and then fall asleep after an hour, because then would normally occur the fourth dream.[4]

## **3 Extreme Lucidity**

### **3.1 The Problem**

As we can see, it is theoretically possible to achieve lucidity with the mentioned traditional techniques, whenever we want to. Unfortunately this skill only have very few people. For the majority it is very hard and complicated to learn to dream lucid. As in every field, talents exist, but the majority of the minority who tries to become lucid has to face several challenges. The first thing to do is having like already mentioned a good dream recall. A dream journal and suggestions help a lot. Nevertheless it is not rare that even advanced oneironauts (dream traveler, often associated with lucid dreamer) have problems with dream recall. A good dream recall sure helps to recognize that one is dreaming, but many reach this crucial point only months of training. Even experienced lucid dreamers often do not have more than a couple lucid dreams per month. This is also counting lucid dreams, which are not really successful. Many especially beginner's lucid dreams do not last more than a second. As soon as one remembers that he is dreaming, he wakes up. Furthermore we of course also want to change the dream world, which however can also speed up the premature awakening. To solve these problem (dream recall, lucid dream induction, stabilization and control) I developed the device ExLu.

### **3.2 The Concept**

But how does ExLu suppose to help? While we dream we are not completely cut off of the outside world. Our brain is monitoring the environment with our senses. Part of that information is processed unconsciously and is integrated into the latent dream content.[2] Everybody is probably

familiar with this phenomenon. Suddenly we dream that something is beeping, and then we wake up and notice that it is our alarm clock that beeps. The influence of those external stimuli on the dream content can be very diverse. On the one hand the stimuli can be displayed directly in the dream. E.g. in one of my dreams a dream person started to make the weirdest noises, then I woke and realized that someone was snoring. On the other hand, the processing can be more abstract. A too warm environment caused my dream to be about being shot with lasers.

This mechanism can aid in lucid dreaming. These external stimuli can be used as dream signs who remind someone, that he is dreaming. ExLu can now use such stimuli to in a sense tell the dreamer, that he is dreaming, if he has prepared himself, that certain things are dream signs. Before we discuss which stimulation we use, we should first ask ourselves, when they should be used. Obviously it has to happen during a dream, but how does a device know that we dream.

### **3.3 REM Detection**

One of the simplest and most common way to detect dreams is to observe eye movement and therefore detecting REM. Our dream body is moving constantly, but the sleep paralysis is responsible that this does not lead to movements of our real bodies. The neurotransmitters and hormones, which are responsible for starting the REM stage cause also a nonreciprocal flaccid paralysis.[6] Some muscles like in our fingers and face can twitch, but the large skeletal muscles are paralyzed. There is however an exception: the eyes. Our real eyes move just as our dream eyes.[1]

Not only does the eye movement tell us when somebody dreams, they also offer a way for the dreamer to communicate with the outside world. Scientists like LaBerge proved the existence of lucid dreams, because they observed eye movement patterns like left-right-left-right, which the oneironaut was told to do, as soon as he becomes lucid.[1]

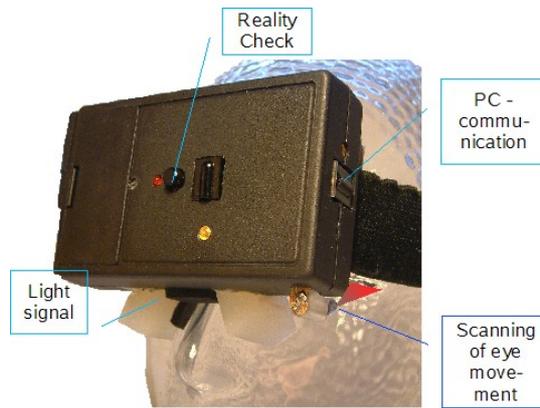
Eye movements can be detected with cameras or measurements of electric currents around the eye. If the direction we look at does not matter, we can use a simple photo electric sensor. This method is used in the “Novadreamer” and other similar projects, which all function by the same principle.

The devices have the form of a sleep mask. Over the eye a photo electric sensor measures the movements of the eye lid. A microprocessor processes this information and can then react with beeps and light flashes through LEDs which are positioned over the eye.

Overall the effectiveness of these lucid dream induction devices are rather humble. Some had positive experiences, but many reported a long getting used to, and that the effectiveness decreased over time or that there was no effect at all.

Still I was optimistic that technology has a great potential to aid with lucid dreaming. I was not satisfied with the current solutions, because first of all they are very expensive, since they cost hundreds of dollars. Furthermore the devices were all very restricted. You can change only a couple settings with the buttons on the device and therefore individual adjustment is limited and rather difficult. There are only a few program sequences and reactions to choose from.

Therefore I wanted to create my own device, which lets me exactly adjust all settings, how and when REM Detection should happen, how it should react when a dream is detected. Especially I wanted to experiment with Neurofeedback and therefore I chose to develop ExLu which gives me complete freedom what kind of stimuli I want to use.

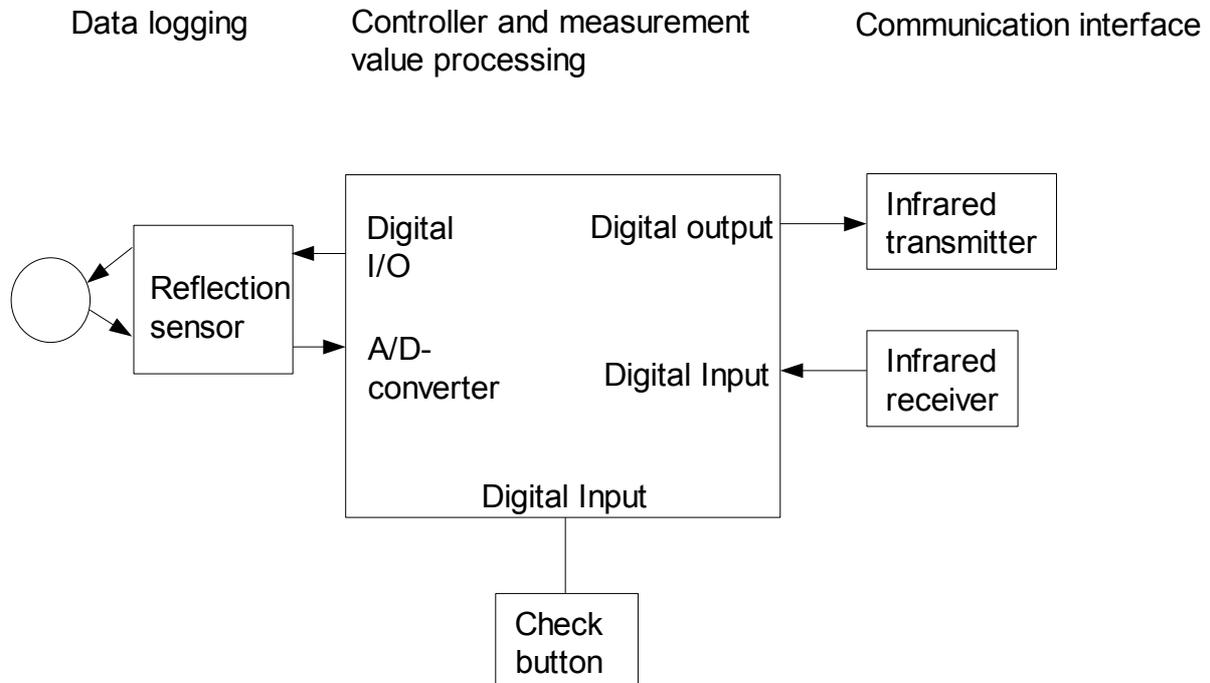


pic. 2: ExLu prototype

### 3.4 ExLu Technical Description

To reach that kind of flexibility, I decided to let a computer software do the main work. The device itself measures eye movement, but instead of it now processing the information and reacting itself which is limited, ExLu sends the data about the eye movement to the computer via an wireless connection. The computer can now analyze in real time the sleep and react depending on what settings were chosen with an unlimited variety of multimedia data. The device itself consists of a box which can be fixed on the forehead with an elastic band. The box contains the conductor board. The photo electric sensor is located on the bottom corner facing the eye. The wireless communication is an infrared connection. A detailed circuit diagram is located in the appendix.

ExLu's core is the PIC Microcontroller. It regulates the data measurement, preprocesses it and communicates with the PC. The photo electric sensor consists of Infrared LED and photo transistor. The Infrared light shines on the eye lid and the light is reflected. The photo transistor then measures how much light is reflected. The more light is reflected the more electricity flows through the resistor.



pic 3: ExLu scheme

When the eyes move, light is reflected differently and therefore the current on the resistor changes, because different light amounts are hitting the photo transistor. The current can be translated into a digital value through a Analogue/Digital converter, which then can be processed.

The computer sends a start signal for measurement and then within 7 seconds the IR LED flashes 30 times and the converter measures the reaction. The data then is send back to the computer via an infrared wireless connection.

## **3.5 External Stimulation**

### **3.5.1 Acoustic Stimuli**

How exactly now does the computer reminds you that you are dreaming? We can use acoustic stimuli like the recorded speech: "You dream". LaBerge had success with this message when applying to experienced lucid dreamers. Five of 15 dreams were lucid dreams and three of them were induced, because they heard the speech during their dream. This method has a huge disadvantage, however: We wake up easily. The speech caused eight awakenings during a night.[1] These results were also observed with ExLu: Either the stimulus strength is too strong and I woke up or it was too weak and I could not hear any messages during my dreams. That is why acoustic stimuli are rather for deep sleepers.

To awaken during the sleep is not necessarily a bad thing. Dream recall increases dramatically when you wake up during a dream, because you generally cannot remember dreams when you continue to sleep after one. My average dream recall is about two to three dreams per night. In a night with ExLu set to play a loud sound after five minutes when REM is detected (to be sure that I am already dreaming and not to wake just when the dream starts) I had an average of 4 dreams during a nine hour sleep. This principle also worked on persons who have not dealt with dreams at all.

I also used this feature to verify that REM-Detection is working properly. When the computer wakes me up, when he thinks I am dreaming and I remember a dream, then REM-Detection works properly. Also interesting is that I often completely ignore the first stimuli. The hypnogram made by ExLu shows, that after 90 minutes after falling asleep, when the first dream occurs, the sound data did not wake me up, since the program records also whether I cancel the stimuli or not, and there is often no cancelling after the sound started. This can be explained with the fact, that the first REM-Stages are short and the sleep is deeper compared to the later ones.

### **3.5.2 Visual Stimuli**

Acoustic Stimuli can aid us with lucid dreaming, but not as effective as one would like. Another possibility would be using vibrations. Those are effective, but the technical realization is complicated and therefore visual stimuli has been proven to be the best option. The advantage is that we rarely awaken from small light sources, because in contrast to sounds, such light does not mean danger for us most times.[1] This was also confirmed with experiments with ExLu. I did not once wake up because of the light.

But which light source is the best one? At first I tried the not yet used source computer

monitor. I let my monitor flash and when I closed my eyes, I saw differences in the illumination of my environment. However, already in the awake state I found the light rather weak and I was worried that it would be too weak for lucid dream induction, too. Within a week I could not observe, that I processed the stimuli in any way. So I decided to use a LED over my eye instead, which is the most common method to induce lucid dreams through technology.

I considered first just having a LED over the right eye, so that the left brain hemisphere is stimulated. I assumed, that since the left brain hemisphere is more responsible for logic than the right, stimulating this brain area would result in an easier recognition of the dream as such. However, neither does the stimulation of only one eye cause the stimulation of one brain side, nor is there any correlation between lucid dreaming and hemisphere activity been observed by the “Max-Planck-Institut” for Psychiatry. I chose a red LED, because in my environment it seems to be less present than other colors, and therefore I would pay more attention to it

Already the first night proved to be successful. After six hours of sleep and therefore in my fourth dream, did the computer detect REM and started flashing the LEDs. My unconsciousness processed this information in an interesting way. I dreamed that I am driving a car and suddenly the car in front of me started to break constantly. Since he was braking and then accelerating and then braking again, the red brake lights did go on and off, in my dream just like the red LEDs in reality. This dream unfortunately also highlights the problems with such induction methods: I did process ExLu's messages, but I did not understand them. We still need a critical consciousness to remember that those signs are a message that we are dreaming, or else we ignore them like I did. We still have to prepare ourselves in the awake world, that red flashing things mean that one is dreaming. On the other hand, I did become lucid in this dream. Some minutes later, something strange happened and I decided to do a reality check. I could breath through my closed nose and I know that I was dreaming. Could this be due to the LED? I used the autosuggestion: “Red means I dream”. Consciously the flashing brake lights did not help me, but unconsciously maybe. I might have associated the red flashing with the goal to recognize that I am dreaming, because of the Autosuggestion.

Many lucid dreams followed, which were induced with light. How much it helped is difficult to say, because the lucid dreaming rate varies significantly and longer studies are needed, but in about two months I had two more lucid dream than usual (three lucid dreams per month are my average without ExLu). The advantage with this method is, that in contrast to MILD without ExLu, you have a more or less definite dream sign you have to look after, instead of virtually infinite possibilities. Still we have the problem that we have to recognize the dream signs as such.

## 4 Neurofeedback

To solve this problem, I asked myself, whether I could somehow improve our critical consciousness, so it would be easier for me to remember what the dream sign means. I wondered whether there might be a difference between the neural activity in normal dreams and lucid dreams, which result in a more critical thinking. At first, there seems to be none. Lucid and normal dreams seems to be neurologically speaking to be the same thing. But then I read studies made by Robert D. Ogilvie, Kevin P. Vieira and Robert J. Small. The brainwave activity seems to be the same in lucid dreams and normal dreams (theta waves with a frequency of 4-8 Hz and slow alpha) activity, but there was more alpha than usual in normal dreams, which then become lucid dreams. Alpha is associated with relaxed wakefulness and therefore we can assume that in those dreams we become lucid, because we are more critical, because we are more awake, because our brain is swinging faster and then turns back to normal activity when we recognized the dream as such. [7] Additionally Thomas Yushak suggests, that also during lucid dreams unique alpha bursts take place, which would also explain, why lucid dream recall and vividness is greater.

([http://www.advancedld.com/f/9\\_HZ\\_bursts\\_correspond\\_to\\_lucidity.pdf](http://www.advancedld.com/f/9_HZ_bursts_correspond_to_lucidity.pdf)) I also suspect, that this could be also the reason, why lucid dreams tend to be so instable and many wake up instantly the moment they become lucid.

The next question is, can we alter our brain waves, so that it would be easier for us to become lucid? Can we somehow stimulate alpha? A possible solution would be the controversial brainwave-entrainment. This is a special form of neurofeedback. Entrainment is a physical phenomenon, in which two oscillating systems are influencing each other and can therefore synchronize each other. This can also be applied to the brain and external stimuli. The brain tends to adapt the dominating brain wave to the frequency of the external stimuli. [9] Many programs claim to be able to do this. I use Neuro-Programmer 2 for my studies. It creates special sounds with special frequencies of beats to entrain the brain. The problem is that like already mentioned sounds are not very useful for lucid dream induction because we wake up fast. Furthermore it is generally not recommended to fall asleep during brainwave-entrainment sessions. For them to have an effect, we must be awake, so that we consciously process them.

However, I showed in this paper, that we do process external information during dreams and I have not found studies about entrainment during REM. That is why my hypothesis is, that entrainment should have an effect when we dream. So I chose to study the effect of certain frequencies of LED flashing. When the LEDs flash nine times a second, alpha activity should raise and therefore we should become more critical. Currently I am experimenting, how exactly when which frequencies should be used. It might be more effective to start with a theta stimulation and then raise it to alpha. Another open question is how long the stimulation should be. With pure 9 Hz stimulation I could raise my lucid dream rate per month to five lucid dreams from three without any technical help and from four using visual stimuli just as dream signs, without the effect of brainwave-entrainment. Whether this success is really one is open, because I did not have yet enough time to present accurate numbers on the average increase of lucid dreams, which could be due to many other factors. Especially the placebo effect might have played an important role. I expected the entrainment to work and so it did, since dreams are very sensible to expectations. My hypothesis that entrainment does have an effect has to be verified with EEG studies. I am currently planing on building one, so I can observe what or whether entrainment has an effect on brain waves during our dreams.

If this proves to be successful, then it could be possible to use this method to stabilize dreams. Maybe a theta stimulation would cause a deeper REM and therefore a longer lucid dream. Since theta stimulation might be counterproductive to the alpha stimulation, it must take place after becoming lucid. But how shall ExLu recognize whether someone is lucid? The answer was already mentioned before: The dreamer performs certain eye movements. ExLu would have to be able to detect in which direction the eye looks or in which direction the eye movement is happening. When the dreamer becomes lucid, he can make left-, right-, left-, right eye movements, which are then detected by ExLu and is a signal to start theta stimulation. Additional photo electric sensor could be used to detect such movements.

## 5 Conclusion

The aim, to build an affordable dream analysis device for home use, was achieved. ExLu recognizes REM reliably and can help anybody to improve dream recall. The lucid dream induction itself works, but leaves room for improvement. In the current state, it is not significantly more effective than traditional induction methods and requires practice. However, because of the unique combination of lucid dream induction device and computer, infinitely more possibilities were opened which provide the user with an enormous flexibility, upgradability and therefore an easy way to improve and extent ExLu. That is why I am optimistic, that “Extreme Lucidity” has a lot of potential to aid everybody with dreaming lucid. Especially exciting is the research on neurofeedback. If my hypothesis proves to be right, then the influence on lucid dreams would be immensely beneficial. It would help those, who want to experience the perfect virtual reality, in which everything is possible and lets us to experience whatever we always wanted. Lucid dreaming provides us a platform for self-improvement. We can train our athletic abilities, solve academic problems and learn, but also use dreams as a source for creativity. There are also more serious aspects to lucid dreaming. Lucid dreams are an incredibly beneficial tool for psychotherapy. An easy lucid dream induction would enable an easy solution for psychological problems, like phobias . If someone is afraid of speaking in front of a large audience, then he can train his speech in lucid dreams. If someone has nightmares, he can become lucid in those and is then therefore not afraid anymore. He can even deal with his unconscious problems and confront them, by e.g. asking the monster why it chases him. This also leads us to another area in which lucid dreams are beneficial: research. Lucid dreams provide us with a way to directly study dreams in the dream itself and also study our unconsciousness. Lucid dreaming opens us a world to knowledge, which we cannot achieve by other means and I hope that I can contribute to that process.

## 6 Acknowledgment

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Last access to the web sites: 17.12.2007

# 8 Image Sources

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All other images were created by the Author.



