



The life review experience: Qualitative and quantitative characteristics

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ABSTRACT

Background: The life-review experience (LRE) is a most intriguing mental phenomenon that fascinated humans from time immemorial. In LRE one sees vividly a succession of one's own life-events. While reports of LRE are abundant in the medical, psychological and popular literature, not much is known about LRE's cognitive and psychological basis. Moreover, while LRE is known as part of the phenomenology of near-death experience, its manifestation in the general population and in other circumstances is still to be investigated.

Methods: In a first step we studied the phenomenology of LRE by means of in-depth qualitative interview of 7 people who underwent full LRE. In a second step we extracted the main characters of LRE, to develop a questionnaire and an LRE-score that best reflects LRE phenomenology. This questionnaire was then run on 264 participants of diverse ages and backgrounds, and the resulted score was further subjected to statistical analyses.

Results: Qualitative analysis showed the LRE to manifest several subtypes of characteristics in terms of order, continuity, the covered period, extension to the future, valence, emotions, and perspective taking. Quantitative results in the normal population showed normal distribution of the LRE-score over participants.

Conclusion: Re-experiencing one's own life-events, so-called LRE, is a phenomenon with well-defined characteristics, and its subcomponents may be also evident in healthy people. This suggests that a representation of life-events as a continuum exists in the cognitive system, and maybe further expressed in extreme conditions of psychological and physiological stress.

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1. Introduction

“My whole life flashed before my eyes” is a common description of the life-review experience (LRE), as people report watching or re-experiencing series of their life-events (Blackmore, 1993). “I was back in my early childhood; and from then on, it was like I was walking from the time of my very early life, on through each year of my life, right up to the present” (Moody, 1975, p. 66), is a description that emphasizes the chronological order of LRE, though different chronological varieties exist as well. Following such reports, LRE has been defined as the vivid perception of images of one's life, encompassing either the person's whole life-span or several significant events (Greyson, 1983; Van Lommel, Van Wees, Meyers, &

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Elfferich, 2001). LRE usually follows a chronological order, mostly from early to late age, but there are also reports of the other way around. The number of distinct life events viewed in LRE may range from several images to the impression of a rapid flow or simultaneous presentation of numerous images depicting one's entire life, and may extend even to the future (Groth-Marnat, 1989; Stevenson & Cook, 1995). Many experiencers describe substantial affective effect of LRE, as is exemplified in the following description: "most things were pleasant to see, some made me very embarrassed. In fact, revulsion and guilt took away any good feelings, making me so very sorry for certain things I had said or done. I hadn't just seen what I had done, but I felt and knew the repercussions of my actions. I felt the injury or pain of those who suffered because of my selfish or inappropriate behavior" (<http://www.iands.org/experiences/nde-accounts/>). Accordingly, LRE is often reported to have a profound impact on the experienter's life (Blackmore, 1993).

Most LREs are reported among people undergoing a near-death experience (NDE), with no correlation to its severity (Osiris & Haraldsson, 1977; Parnia, 2014). A prospective study of survivors of cardiac arrest found that 8 out of 62 (13%) resuscitated who experienced NDE also reported a LRE (Van Lommel et al., 2001). Another analysis of several hundred NDE cases found 24% of them to report some degree of 'revival of memories' during the experience (Kelly & Kelly, 2007, p. 386). Not only NDE, from 205 persons who had encountered life-threatening danger, 60 survivors described an experience resembling LRE or "panoramic memory" of their life (Dlin, 1980; Noyes & Kletti, 1977). Interestingly, LRE was also described in aged-people elaborating on their anticipated death but not among suicide attempters (Butler, 1963; Rosen, 1975).

Several theories attempted to explain LRE's underlying mechanism. From a psychological point of view, Greyson (1981) characterized LRE as a hallucinatory escape from the actuality of death by a 'mental time travel' to "past experiences of a relatively timeless quality" (Noyes & Kletti, 1977), though LRE may include images from all phases of life, and the experience may be experienced as unpleasant or fearful (Blackmore, 1993). Another psychological motivation may be the need to reassess one's life achievements, a motivation that may apply to such a mental process also in individuals who never explicitly described an experience of LRE (Butler, 1963). LRE may also be explained with respect to the underlying functional neuroanatomy. Several authors have argued that decrease in blood oxygenation, derived of low blood pressure such as in temporary cardiac arrest, may account for the different clinical manifestations of NDE. One proposal is "cascade of events", starting with neuronal disinhibition in early visual cortex, spreading to high-order ones which may lead to a more complicated cognitive experiences (Blackmore, 1993; Greyson, 1998; Rodin, 1980). Another proposal relates NDE's manifestations to hypoxia in specific regions, such as tunnel vision due to suffering of the optic nerve, or out-of-body experience due to reduced blood flow to a "water-shed" region at the temporo-parietal junction (Blanke & Arzy, 2005; Mobbs & Watt, 2011). LRE may therefore be related to altered activity in "water-shed" areas in the prefrontal, medial temporal or parietal cortices, which process autobiographical memories (Arzy, Collette, Ionta, Fornari, & Blanke, 2009; Bancaud, Brunet-Bourgin, Chauvel, & Halgren, 1994; Blackmore, 1996; Gloor, 1990; Penfield & Jasper, 1954; Vignal, Maillard, McGonigal, & Chauvel, 2007).

NDE generally appears in people in life-threatening situations. However, its components, such as out-of-body experiences, are also found in as much as 10% of the general population and in patients with several neurological and psychiatric disorders (Blackmore, 1993; Blanke, Arzy, & Landis, 2008; Blanke, Landis, Spinelli, & Seeck, 2004; Gabbard, Twemlow, & Jones, 1981; Irwin, 1985). While out-of-body experiences drew much scientific attention in the recent years (for review see (Blanke, 2012)), this was not the case with LRE. Moreover, the phenomenon of out-of-body experience was not only important by itself, but also taught us much about bodily processing and spatial aspects of the human self (Blanke, 2012; Blanke & Arzy, 2005; Blanke & Metzinger, 2009). As out-of-body experience is the hallmark of spatial alterations in NDE, LRE is the hallmark of temporal alterations. Thus, LRE may be important to the understanding of temporal aspects of the self. Moreover, the cognitive research of autobiographical memory focuses mostly on discrete life-events rather than the continuous life-experience as in LRE (Brunec et al., 2015). LRE may therefore prove to be significant for the neurocognitive understanding of the self in time and extended autobiographical memories.

In view of the central role of re-experiencing the continuum of one's life-events to the temporal self, we hypothesized that the subcomponents of LRE may be found also in the healthy population. To this aim, in the present study we characterized the phenomenology of LRE, and then investigated its radiation in the healthy population. Following recent recognition in phenomenological psychology that quantitative and qualitative research methods should complement each other (Brewer & Hunter, 1989; Campbell, 1975; Cook, Campbell, & Day, 1979; Cronbach, 1975; Firestone, 1987; Gage, 1989; Glesne & Peshkin, 1992; Patton, 1990), we used here first qualitative analyses and in-depth interviews to characterize LRE, and then quantitative measurements on a large cohort of subjects, to evaluate the prevalence and characterize varieties of the LRE in both healthy subjects of different ages and backgrounds as well as patients with NDE/LRE.

2. Methods

2.1. Qualitative experiment

Participants. 7 patients (4 males) that underwent LRE as part of an NDE were analyzed in the qualitative part of the study. 4 patients (2 males, mean age \pm SD: 47.7 ± 7.1 years) were recruited for the study and interviewed by the authors, while 3 more (2 males) were analyzed from online video descriptions. All recruited patients gave informed consent before participation in the study.

Procedure. A semi-structured in-depth interview was used in order to collect detailed data regarding patients' LREs. Patients were encouraged to share only experiences they remember with high confidence. The interview started with questions regarding patients' demographic information (current age, age at time of the experience, religion, occupation, ethnicity, country of birth, marital status, residency). In addition to a detailed phenomenological description, we have inquired for content and characters of the LRE according to the following topics: order of events, continuity, period, valence, emotional content, life evaluation, perception in the LRE, feeling of reality, point of view, and role of others in LRE. The average duration of an interview was approximately 90 min. The interview was videotaped and transcribed verbatim. Participants were assured of anonymity and all gave permission for the recordings procedures. These transcripts were further used for data analysis.

Box 1 The life review experience scale.

This questionnaire presents 34 statements about how you might experience your autobiographical memories. Please read them carefully, determine to what degree the experiences described apply to you, and choose the answer that best reflects your experience on a scale of 1 (completely disagree) to 6 (completely agree).

These are subjective questions; there are no right or wrong answers, just answer to the best of your judgement.

- 1 Sometimes I suddenly remember an event I was never aware of before.
- 2 Sometimes I have the feeling that a lot of memories are coming back to me all at once.
- 3 Sometimes I re-experience memories so vividly or full of color that they appear like an intensified reality to me.
- 4 Sometimes I re-experience an event I regret as if the event is happening again in my mind.
- 5 Sometimes I re-experience an event from another person's point of view, as if I am that other person.
- 6 Sometimes I feel as though I'm watching a memory from outside myself, as a spectator.
- 7 Sometimes I experience memories as seemingly different versions of my life, as if my life could develop on different ways.
- 8 Sometimes a memory that feels like I'm re-experiencing an event makes me realize something I hadn't realized before about another person.
- 9 Sometimes I experience a feeling of "everything makes sense now" after recalling a memory.
- 10 Sometimes a memory feels sped up, as if I'm remembering it in fast motion.
- 11 Sometimes when I remember past events, time in reality passes by very quickly.
- 12 Sometimes my memories feel like a movie.
- 13 Sometimes I choose which life memories I want to recall.
- 14 Sometimes I recall memories in the chronological order in which they really happened.
- 15 Sometimes a memory stays sharp in my mind after I remember it.
- 16 Sometimes memories feel like a dream to me.
- 17 Sometimes I feel like I am reliving my memory as if I'm going through the event again.
- 18 Sometimes I re-experience a memory in an extremely detailed manner, noticing small details in the event.
- 19 Sometimes I re-experience events as a series of separate images.
- 20 Sometimes I remember something but then the memory slowly fades away.
- 21 Sometimes I feel that the recall of a memory/memories changes my life perspective.
- 22 Sometimes I feel that the recall of a memory/memories turns me into a different person.
- 23 Sometimes I feel that the recall of a memory/memories turns me into a more spiritual person.
- 24 Sometimes while I remember something it feels like I am in more than one place at the same time.
- 25 Sometimes I feel like the experience of recalling memories has a positive influence on me.
- 26 Sometimes I criticize myself for hurting others when I remember something.
- 27 Sometimes I have feelings of peace and pleasantness after recalling memories.
- 28 Sometimes I have a feeling of remembering events that have not yet happened.
- 29 Sometimes I feel like I remember different versions of my future, as if I've already experienced them.
- 30 Sometimes I experience a *Deja-Vu*, an experience which feels like it already happened.
- 31 Sometimes I feel anxious when I think about the future.
- 32 Sometimes when I remember past events I think about things I could have done differently.
- 33 Sometimes when I remember an event I feel sorrow and pain because of my actions at that time.
- 34 Sometimes when I remember a past event I feel like someone else is present with me.

Have you ever had a "Life Review Experience" in which you saw much or the totality of your life history in chronological sequence and in extreme detail? YES NO

If you did, could you please describe it thoroughly?

Data analysis. Each transcribed interview was deconstructed sentence-by-sentence to identify key components. Names were assigned and example quotations for each component were noted. Themes were identified by a close study of the data by the authors, who reached consensus on those of greatest relevance to LRE's phenomenology. These components were compared across interviews to identify components that extended beyond the original ones. We have sorted these components into groups, and calculated frequency of their appearance in the descriptions. Main characterizing quotes were extracted for each patient and component.

2.2. Quantitative experiment

Participants. Participants were recruited over the social media in the year of 2014. 264 respondents (mean age 31.4 ± 13.5 years, 90 male) participated in the study. Participants rendered anonymous during the recruitment and analysis procedures, after agreement for participation in the study.

Demography and meta-data. Participants were asked to indicate their gender, age, mother tongue, level of education, religion and level of belief, country of birth, ethnicity, residency and marital status.

The LRE scale. The LRE scale is a 34-item self-report questionnaire that uses a 6-point Likert scale to measure the degree to which respondents endorse statements about the components of LRE (Box 1). These components were derived from the above qualitative interviews. Components of LRE, which appeared in more than one description, were incorporated in the scale, including content, thought processes, affective states, accompanied sensations, perceptions and long term radiations. Responses were summed to yield an overall score of LRE components in everyday life. Additionally, in the end of the questionnaire we asked participants whether they have experienced a full or partial LRE. They were asked to describe it thoroughly, and leave their contact details if they were interested to participate in further research.

Dissociative experience scale (DES). The DES (Bernstein & Putnam, 1986), a validated measurement for dissociative symptoms intensity in research and clinical settings, was run on a subsample of the participants ($n = 36$, 18 males, age: 51 ± 19.4 years), as a control variable and in order to differentiate between LRE and dissociative states. The DES, developed for measuring the frequency of dissociative experiences, includes 28-items regarding dissociative experiences (Carlson & Putnam, 1993). Typical items of this scale are "Some people have the experience of finding themselves in a place and have no idea how they got there" and "Some people find that sometimes they are listening to someone talk and they suddenly realize that they did not hear part or all of what was said". Participants had to scale the percentage of time in which such experiences happened to them. The mean score comprises the final DES score (Arzy, Mohr, Michel, & Blanke, 2007; Bernstein & Putnam, 1986).

Statistical analysis. For each subject, an overall LRE-score was computed by summing the 1–6 scale responses for all items. A final score could range from 34 to 204. Testing for normality of scores distribution among participants was conducted by a Shapiro-Wilk test. In addition, an average score and standard deviation (SD) were also computed for each item in order to assess prevalence of these components in our participants. Correlations between demographic data and LRE-scores were calculated, as well as correlation between items. Correlation was calculated also between LRE and DES scores. Mann-Whitney *U* test was used in order to test for significance.

3. Results

3.1. Qualitative results

All phenomenological results are detailed in Table 1 and summarized in Table 2. We first investigated the temporal characters of LRE, including order, continuity and time period of the LRE. With respect to the order of experiences in LRE, 2 patients mentioned a chronological order ("information of what you did, from the moment you were born, to the moment that you died"); 2 mentioned an associative order ("one experience of an event might lead to a constellation of other related experiences"); 1 patient reported a random appearance of significant events ("I saw a few events that were special to me"). The continuity category addressed progression and flow of events. 2 patients with LRE described their reviews as continuous, a "movie-like" experience ("it was like a flashback, like watching a movie flashes back before my eyes"), while another reported seeing separate images running in a succession ("my whole life was shown to me in a series of quick images that moved really fast"). 2 patients reported a combination of these two ("like a multi-dimensional video for the most part, with occasional still pictures"; "it was like holograms inside holograms inside holograms"). 4 patients described a simultaneous appearance of the LRE ("it's simultaneous, you know it all, simultaneously"; "it wasn't fast, it wasn't speeded, it was just instantaneous"). The period of time reviewed during LRE was either the patient's whole lifetime ("... information of what you did, from the moment you were born to the moment that you died") as described by 3 patients, or sections of it ("only certain sections of my life stood out") as described by 2 patients. Interestingly, in 2 patients the LRE was further extended into the future ("I also saw my possible future, I still have déjà-vu of the events that I remember from that experience").

Another central theme of the LRE is affect. By 'valence' we refer here to the intrinsic attractiveness of the LRE to the experiencer. 4 patients referred to the valence of the LRE itself ("I suddenly knew who I was; and I could accept that this is who I am"), while 3 others mentioned significant scenes or encounters ("I passed by familiar characters of people that already passed away"; "they reminded me of some past events"). The LRE itself also evokes emotions in the experiencers. 3 patients

Table 1

Detailed phenomenological descriptions. Results of the qualitative study are presented including subcategories and patients descriptions.

Nr.	Category	Mode	e.g.	N
1.	Order	Chronology	"Information of what you did from the moment you were born to the moment that you died"	2
		Associative	"My life review did appear to be shown to me in chronological order" "One experience of an event might lead to/include a constellation of other related experiences" "The order would be your immediate family. Then the "packing order" became, my father, his parents, my mom's parents, and the dog at the end ... there was some degree of packing order but I really didn't think of it, it was just coming towards me, in my experience."	2
		Random	"I saw a few events that are special for me."	3
2.	Continuity	Video-like	"A film, it felt like I'm sitting in the cinema" "It was like a flash back, like watching a movie flash back before my eyes"	2
		Separate images	"My whole life was shone to me in a series of quick images that moved really fast."	1
		Mixed/multidimensional	"Like a multi-dimensional video for the most part, with occasional still pictures. Like holograms inside holograms inside holograms." "It reminds me of a hologram room on the Star Trek series. You are experiencing a seemingly real event but you are in a different place."	2
		Simultaneous	"I may have been drawn to what we in human minds would call one event, but it immediately became the constellation of events - a complex sort of ... flock. Events inside events that are also other events that are within events and include other events. [...] It was deeply detailed. How many events? That's impossible for me to answer, because the events weren't separate. What we might call one event included, from that point of view, what we might separate out at 8 or 200 other events ... they weren't separate from the perspective that I was using. So I could say one event (this life) and that would be accurate, and/or I could say 10,000+ events and that would be equally accurate." "All things are happening simultaneously, there is not a linear progression, there is lack of time limits [...] It was like being there for centuries. I was not in time/space so this question also feels impossible to answer. A moment, and a thousand years ... both and neither. It all happened at once, or some experiences within my NDE were going on at the same time as others, though my human mind separates them into different events." "It could have been a long process, I wasn't in a time limit. There is no time there, there is nothing to reference it to. It would be unfair for me to put a time on it. If I had to guess my best guess would be 20–30 min, it could have been longer, but I could be wrong. Fairly quickly, probably my time 15–20 min, but their time it was probably 10 s." "It's simultaneous, you know it all simultaneously. It wasn't fast it wasn't speeded, it was just instantaneous." "My life was shown to me in a short period of time, The review itself felt like it took less than a minute or so. It is hard to estimate time. Quick images that moved really fast. It was as if a fast moving camera was reeling through my life. Time felt different during those moments like it could be sped up or slowed down [...] my life review was moving fast but it slowed down during a few sections when I wanted to focus on a certain part of my life, it was speeding through each scene that should of lasted a long time but it didn't. Time seemed to be operating on a different level. The images were moving so fast I couldn't see them but I knew it was my life."	4
3.	Period	Whole life	"Information of what you did from the moment you were born to the moment that you died." "Because I saw my entire life and I got to see it through other people's perspective..." "My whole life was shown to me"	3
		Events	"Only certain sections of the life review stood out: The one part that I remember well is the deck on the lake reeling image. It was evening and the sun was going down ... somewhat orange in color. (My mom and my father were there and I think my brother was standing on the deck. My family members were near me as I walked on the deck). This part stood out." "Events in which I was not ok, were mentioned to me by a group of people in the hall, another character present started mentioning events that show I have been a good person."	2
4.	Valence	Meaningful understanding	"I was interested in creative potentials, how they were expanded, deepened; new potentials, surprising possibilities..." "The joy inside of me, of my personality, the joy of who I am... and I haven't fully chosen that when I was alive." "I Suddenly knew who I was, and I could accept that this is who I am" "I wanted to see a special happy moment with my family."	4
		Encounters	"My life review was about my family members coming forward and sharing their experiences, I was transferring mine [...] I was seeing, feeling these things about him (my father), and he was sharing with me the things of his early childhood and how things were difficult for him. [...] but the information made sense. I was being able to read their experiences. I would get to feel what they had been through in life, their experiences." "I could individually go into each person [encountered in LRE] and I could feel the pain that they had in their life prior to going. Understanding that these people like me, lived lives and caused pain, and got through painful situations, I got to see how they got past that point, I was allowed to see that part of them and feel for myself what they felt..."	3

Table 1 (continued)

Nr.	Category	Mode	e.g.	N
5.	Emotions	Positive	<p>"I experienced this through her, I was the receiving end, I was inside her, and I received my own actions, the consequence of my own actions."</p> <p>"I passed by familiar characters of people that have already passed away, they had only faces, they reminded me of some passed events."</p> <p>"Pleasure, joy, humor, curiosity, relaxed, interested."</p> <p>"I felt very loved and well received, no hard feeling [...] level of greatness happening to you, you can't explain, an overwhelm of love and emotion, that you belong."</p> <p>"I felt a sense of surprise and comfort."</p>	3
		Negative	<p>"I also felt the sadness that they had gone through."</p> <p>"I was sad. I did have that emotion, it was not pleasant. I was like nooooo, I could have done so much more with my life..."</p> <p>"This life review which for me was very painful."</p> <p>"I heard what I did and I was ashamed"</p>	4
6.	Life evaluation	Judgment	<p>"I was evaluating what I've done in my life, but I was evaluating it on my own terms, on my own sense of what I had wanted to do or what was fun for me. [...] No judgment - you can't hurt other beings (people) really, because we're not people - we're non-physical beings having an experience within physical reality. Like we're in a movie - you can't hurt the actors no matter what you put them through in the movie's story because they are not that character, they're just playing a role..."</p> <p>"No judgment, just for me to watch and to observe."</p> <p>"It's your own judgment, it's me, I'm realizing, because of my experiences were true, now I'm realizing the pain that I've done, but it's not the light or you could say god that is judging me, there's is a different here."</p>	3
		Learning/realizing Choices	<p>"That learning while maybe painful, of coming to realize something you were unaware of..."</p> <p>"When I was in my life review, you might think of it as I was looking at the chunk of the tree of all the choices I did take and that was the main focus, but I could also see all the branches, going of, and where those might have led if I had chose to carry my focus in that direction, my primary focus."</p> <p>"I had made some choices that I could have made better. I could've chosen more for [my daughter] ...". Life could have been more joyful...</p> <p>Now I'm back in the third review. And in this review, it is one in which I made those choices and I have lived those choices of what I like and what was important to me."</p>	1 2
		Alternatives	<p>"Then I'm back in front of the amphitheater and the life review begins again, but this time, the contemplation I have had of what I could have done, what I have chosen for myself, the opportunities"</p>	1
		Regrets towards others	<p>"All the scenes, starting from a fight with my mother where I've been angry at my mother and maybe she would cry, so I would experience her pain, of me causing her pain, I would go through an x-girl friend, I'd been be really bad to her so she would be crying. I would go all the way to third grade, I was teasing a girl, she was against the wall and I was calling her names and she would just cry and cry. I experienced this."</p>	1
		Regrets towards self	<p>"I didn't regret them as I reviewed them, and I was totally indifferent to whether I may have regretted them within the human mind, the human personality or lifetime."</p> <p>"Not being able to be there, was one of them (things regretted), not being able to spend time [...] that feeling of loss of times, things that maybe could have made a difference, not being able to be there was one of them, not being able to spend time when he has sick, that feeling of loss of times, things that maybe could have made a difference."</p> <p>"I felt guilty for not being more loving toward myself and nice to others."</p>	3
7.	Perception	Awareness to details, vividness & colors	<p>"You can become aware to every single peace that led to this moment in every single way, it could be that butterfly wing thing... It's that detailed if you want to focus there. Being able to see those layers and details..."</p> <p>"I was wide awake, it was very detailed, Everything that I experienced, as far as vision, it was very clear, everything was very detailed."</p> <p>"It zones before you with all colors and information, of what you did from the moment you were born to the moment that you died."</p> <p>"The vision was in color [...] I saw the vivid image of my family hanging out near a deck on a lake"</p>	4
		Senses	<p>"All the senses are informing each other. Those senses were extended and inter-connected."</p> <p>"You're are able to see with that type of sharp clarity. [...] I did feel alot of things. There I had a heightened sensitivity, almost euphoric in everything you experience. When I say heightened sensitivity, awareness, both emotional..."</p> <p>"I don't recall any sound or smells during the life review but their was some sound during the deck scene the senses that were most dominant include vision and physical sensations."</p>	3
8.	Feeling of reality	Dream	<p>"Daydreaming it wasn't part of the recuperating, it was just so casual, you don't really care what you are day dreaming about."</p> <p>"My worldly experiences felt like a dream"</p>	2

(continued on next page)

Table 1 (continued)

Nr.	Category	Mode	e.g.	N
		Reality	"both like dream and reality"	2
		Stable memory	"Yes, it did feel real. I felt like an observer watching my life. Like I was an invisible stranger in the background watching my life. The scenes felt like they were taking place right then and there."	2
10.	Point of view	3rd person perspective	"It's pretty much embedded, something is going in long term and some in short term and this experience is going in long term for me, in terms of being able to access information. [...] I just remember things about the life review, with pretty good clarity, it stays solid." "This memory stays very solid since, no matter how many times I tell the story it never changes even a slight bit."	5
			"Reviewing from different perspective. . . First perspective, third perspective, some of each." "I watched my life. [...] It's like an amphitheater" "I saw my entire life and I got to see it through other people's perspective." "It was as if someone was showing me my life on a screen. My whole life was shown to me I felt like an observer watching my life. It was as if my life events were set on replay for me." " . . . All the scenes, starting from a fight with my mother where I've been angry at my mother and maybe she would cry, so I would experience her pain, of me causing her pain, I would go through an ex-girl friend. . ."	5
11.	"Lessons"	Judgment	"Judgment of emotions, events, actions are a physical mind/reality choice phenomena. They don't matter. They're not real."	2
		Connections	"Acceptance - I may not be a perfect person but I can accept this is who I am." "Everything that I experienced, as far as vision, it was very clear, everything was very detailed, and we're above all this. It's just really whether you're going to make a difference in the world, whether you're interconnected." "That we could all experience something together."	3
		Communication	"We are here to love. Unconditional love is very important. Life is special." "Feeling comfortable, knowing you can still communicate with loved ones, and they can still communicate with you." "My family needed me and I needed them."	2
		Death	"I don't have to be worried about death. I already know what's on the other side, what is greeting me"	1
		Time	"Time is the most valuable resource we have, most important to me - my family, developing myself."	1
		Understanding life	"This is to help you understand life and choices and joys." "All of our life experiences, need to be enjoyed, the good and the bad"	3
		Will to live	"It made me understand I need to be more with my family and be a better person." "It was like they wanted to show you really what you are going to give up, if you decide to go back" "Ok this is it, I want to go back, send me back. I'm going back." "The life review made me want to return to this reality." "After discussing my life, the characters asked me if I would like to go back, I wanted to go back because I did not finish what I was supposed to do."	4
12.	During NDE		"First I met with thousands of beings, then I rested deeply, then I did what people call an LRE. I then returned to the large group of beings, then chose my injuries, then met with some other beings, then returned to my body. So maybe the LRE was in the middle of the experience." "My life review experience came right at the begging, I had my out of body experience with the light when I lifted up, the guide coached me, came out of the light, and that's where I had my life review."	2
13.	Future	Own life prediction	"I predicted the future for my own life" "I also saw my possible future, I still have deja vu of life events that I remember from that experience."	2
14.	Controlling experience		"Yes. I was in control of the whole experience." "I don't know for sure if it was me who was in control of speeding up or slowing down the life review. My mind's curiosity to select certain significant scenes may be the reason why the life events slowed down for me to observe."	2

mentioned positive feelings such as love, connectedness and comfort ("I felt very loved and well received, no hard feelings"; "level of greatness happening to you, you can't explain, an overwhelming love and emotion, feeling that you belong"). 4 patients mentioned negative emotions ("this review, which for me was very painful"). 1 patient mentioned both positive and negative feelings during LRE.

A recurrent theme in patients' reports involves self-evaluation. 3 experiencers clarify often that despite of potential regrets or frustration that may evolve in an LRE, the experience did not carry any judicial character ("I was evaluating what I had done in my life, but I was evaluating it in my own terms, in my own sense of what I wanted to do, and what was fun for me"; "no judgment – you can't hurt other beings. . ."). 1 patient mentioned a positive experience of 'learning' or 'realization', rather than regret ("that learning, sometime painful, coming to realize something you were unaware of. . ."). 3 patients mentioned

Table 2
Summary of phenomenological results according to categories.

Patient	Order	Continuity	Period	Future events	Valence	Emotions	Evaluation	Perception	Perspective
1	Chronological	Simultaneous	Whole life	–	Significant events	Negative	Judgments, Choices, Regrets	Details	3rd person
2	Chronological	Separate images, Mixed	Events Whole life	+	Significant events	Positive	–	Details, Senses	3rd person
3	Associative	Simultaneous, Mixed	–	+	Significant events	Positive	Judgments, Choices, Regrets	Details, Senses	3rd person
4	Associative	Simultaneous, Video-like	–	–	Encounters	Positive and Negative	Regrets	Details, Senses	1st person
5	Random	–	Events	–	Encounters	Negative	–	–	1st person
6	Random	Video-like	–	–	Encounters	Negative	Judgments, Regrets	–	3rd person
7	Random	–	Whole life	–	Significant events	–	–	–	3rd person

regret (“*I felt guilty for not being more loving toward myself and nice to others*”). These sometimes lead to a “re-biography” (Rotenberg, 2004), in which patients rephrased and reevaluated parts of their own life (“*then I’m back in front of the amphitheater and the life review begins again, but this time, the contemplation I have had of what I could have done, what I had chosen for myself, the opportunities. . .*”).

Patients also mentioned different aspects related to perception of their LRE. These include intensified awareness to details (“*you become aware of every single piece that led to this moment in every single way; “it’s that detailed, if you want to focus there, being able to see those layers and details*”), vividness and colors (“*the vision was in color*”; “*I saw the vivid image of my family hanging out. . .*”). All patients depicted mainly visual experiences (“*I don’t recall any sound or smells during the life review, but there was some sound during the deck scene. . .*”; “*the senses that were most dominant include vision and bodily sensation*”). 2 patients characterized their experience as a dream (“*my worldly experiences felt like a dream*”), while other 2 emphasized its reality (“*I did feel it real. I felt like an observer watching my life. . . the scenes felt like they were taking place right then and there*”). With respect to the experiencer’s point of view, 5 patients observed the LRE from a third person perspective, (“*It was as if someone was showing my life on a screen*”; “*my whole life was shown to me, I felt like an observer watching my life.*”; “*it was as if my life events were set on replay for me*”). Interestingly, 5 patients experienced LRE through an altered experiencer, which may be either an explicit third person (“*I experienced this through her, I was the receiving end, I was inside her and I received my own actions, the consequence of my own actions*”), a reduplication of the self resembling he-autoscopy (“*it feels like I am in more than one place at the same time*”), or a feeling-of-a-presence (“*when I remember a past event I feel like someone else is present with me*”) (Arzy, Seeck, Ortigue, Spinelli, & Blanke, 2006; Blanke et al., 2008; Brugger, Regard, & Landis, 1996).

3.2. Quantitative results

3.2.1. LRE scale

The above categories served as a basis for the LRE inventory, which was completed by 264 healthy subjects. The scale was highly reliable, as reflected in an internal consistency (Cronbach’s alpha coefficient of $\alpha = 0.895$). Responses were summed to yield an overall score of LRE components. Average of total results was 118.4 ± 24.5 (range: 34–204), normally distributed over subjects (Shapiro-Wilk test: $W = 0.99$, $p = 0.24$, Fig. 1). Notably, 13 participants who experienced LRE showed a higher score with respect to healthy age-matched people (136.9 ± 26.5).

Statistical analysis revealed several interesting findings: Age was found to be negatively correlated with the LRE-score (Pearson’s correlation analysis $r = -0.194$, $p = 0.003$). No significant differences were found between people from different cultures and languages. With respect to prevalence of LRE components in the normal population, the most frequent components were the feeling of déjà-vu, regrets and pleasantness. These were followed by chronological order of memories, feeling of significance, insight about another person, active choice of memories, re-experiencing events and thinking about the future. Expansion of the self in space and time, personality changing, spirituality and presence of others were found to be less frequent in the general population.

3.3. Dissociative experiences scale (DES)

Analysis of the DES-scores revealed an average score of 9.6 ± 6.2 (on a 0–100 point scale). In a ranked correlation analysis, subjects’ DES-score was positively correlated with the LRE-score ($p < 0.005$, Spearman’s rho effect size = 0.445; The explained variation coefficient R square = 0.144). No significant relationships were found between the DES-score and demographic information (age, sex, education, marital status, and place of residence). The LRE-scores for this subgroup were comparable to the rest of the group (average LRE-score = 116.3 ± 26.1).

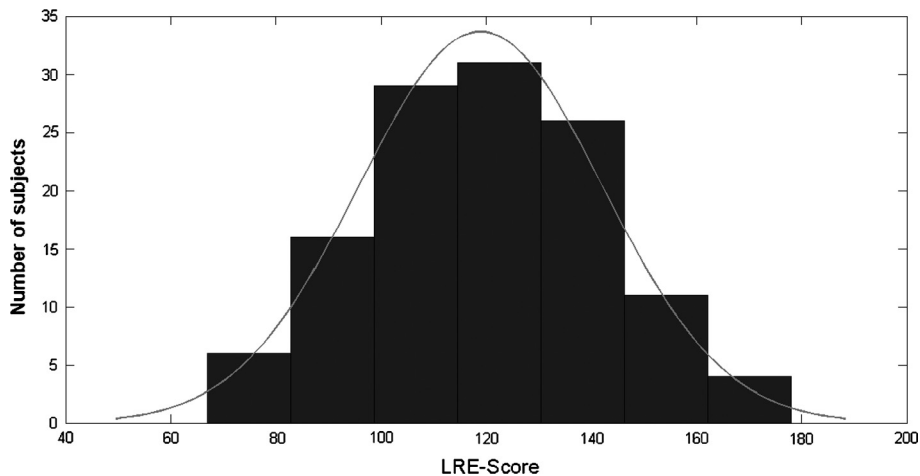


Fig. 1. Quantitative results. A. Histogram representations of total LRE score. Note the normal distribution of overall results.

4. Discussion

In this study, we first used qualitative narrative psychology to interview people that experienced LRE. This approach enabled us to extract fundamental characteristics of LRE, their relations to life events and the subjective experience. Our results led to a quantifiable inventory, which was further applied into a widespread Internet-based survey in order to quantitatively investigate LRE in healthy subjects as well as in NDE patients. This combined approach revealed several new findings about the phenomenology of LRE and its reflection in the normal population, which we discuss in the following.

The organization of life events along a “mental time line” in human cognition and in the memory system is unclear (Arzy, Collette, et al., 2009; Brunec et al., 2015; Burt, Kemp, & Conway, 2008; Burt, Kemp, Grady, & Conway, 2000; Janssen, Chessa, & Murre, 2006; Schulkind, Rahhal, Klein, & Lacher, 2012). Most studies suggest that people “move” from one memory to another according to common thematic contents rather than temporal proximity (Brown & Schopflocher, 1998; Burt, Kemp, & Conway, 2003; Lam & Buehler, 2009; Mace, Clevinger, & Bernas, 2013). However, temporal order may also serve as an organizing principle (Arzy, Adi-Japha, & Blanke, 2009; Brunec et al., 2015). LRE is known to appear in a chronological order (Blackmore, 1993), supporting a potential chronological organization of memories in the human brain. Chronological order of memory retrieval may hint on such a representation in the human cortex, that may be altered in certain situations such as NDE/LRE. In our cohort, only 2 out of 7 patients reported chronological order in their LRE (Loftus & Fathi, 1985; Skowronski & Walker, 2004; Skowronski, Walker, & Betz, 2003; Whitten & Leonard, 1981), while others reported a non-chronological order, which may be a run of associations or a random order (James, 1890). This suggests that a continuous “run” of events may be organized in the human brain in several manners, chronological or associative.

The LRE is often regarded as a distinct element, appearing in the phenomenology of NDE. However, in-depth analysis of LRE shows this experience to present diverse phenomenological characters. A major character of LRE is its significance to the experiencer. All interviewees mentioned a “change” of perspective especially with respect to significant others in their life, and content of their own life events. The role of significant others in mental life were highlighted in the psychological literature (Sullivan, 1953). Several recent studies identified the distinction between close and less-close others, implicating mostly lateral temporal and posterior cingulate cortices (Hassabis et al., 2014). These cortices are part of the watershed areas, which are more vulnerable to suffering in case of decreased blood supply to the brain, as in LRE. Significance (or valence) was mentioned by all interviewees, mostly as a post-LRE attempt for better relations with close people (Larson & Tobin, 2000) and for meaningful understanding of life events.

LRE was seen in 5 of our interviewees from a third-person-perspective. This is similar to the out-of-body experience (Blanke & Arzy, 2005) which also adopts this point of view and often accompanies LRE in patients who undergo NDE. Third-person-perspective is anatomically related to the temporo-parietal junction, a brain region included in the watershed areas that may suffer during hypoxic states, as is the case in many LRE/NDE patients. Watershed areas were also implicated in one’s orientation towards significant events and people in one’s life (Peer, Salomon, Goldberg, Blanke, & Arzy, 2015). Taken together, watershed brain regions disturbed in LRE include mostly regions which do not necessarily monitor episodic memory per se but specific kind of memories regarding the subject’s significant history as well as one’s own perspective and mental-orientation towards this history.

Our quantitative results demonstrated that LRE components are prevalent in varying degrees in the general population. These results suggest that the LRE phenomenon is based on an alteration of a common neurocognitive mechanism shared by the general, healthy population. Scores were normally distributed in the population. We assume that LRE reflects the potential to represent a sequence of life event (in either chronological or associative order) as a continuous experience in the healthy population. As people move along the time line (so-called mental time travel; Arzy, Collette, et al., 2009; Arzy,

Molnar-Szakacs, & Blanke, 2008; Tulving, 1985, 2002), some kind of temporal organization should apply (Arzy, Adi-Japha, et al., 2009; Brunec et al., 2015). LRE may therefore serve as an extreme manifestation of this temporal organization. Not only with respect to the general score, items that were more common in the general population were the most abundant in people with LRE, appearing in more accounts of our interviewees (feeling of déjà-vu, regret with respect to certain events and a general feeling of serenity). Comparably, items that were found as rare in the normal population were also less frequent and prominent in patients with LRE (shift in point-of-view, or uncommon states such as feeling of spirituality or personality changes). This endorses further our hypothesis regarding a potential relation between LRE and cognitive functioning in healthy people.

Although the LRE score correlated with the DES score, this correlation is not significant for interpretation, due to the extremely low scores applied in the DES (floor effect). Moreover, dissociative experiences as reflected in the DES are not normally distributed in the population, unlike the LRE scores. We found a negative correlation between the LRE score and participants age, though with a minimal effect size. While one may expect an increase in the LRE score as long as age advances, our results may hint on the prominence of the life-review phenomena in younger ages, which may carry an evolutionary advantage of future planning (Schacter et al., 2012; Suddendorf & Corballis, 2007).

Our study is not free of limitations. Due to the rarity of full-blown LRE (even in people who underwent NDE), we qualitatively analyzed accounts of a limited amount of subjects. However, 7 subjects are relatively sufficient for a qualitative study, and gave us a coherent reflection on LRE. The data's coding and categorization method directly influences its analysis and interpretation. Categorization can dictate the way themes are generated, the way these themes are integrated in subsequent analyses, and ultimately the conclusions drawn from the study (Constas, 1992). Categories were further translated into a well-defined item to face further validity in the quantitative part of the study. In addition, since our interviewees volunteered to participate in the study, it could be plausible that they share some common features that are not necessarily represent patients with LRE in general. It is possible that only people who had a positive and significant experience wanted to share it, and that the psychological consequences apparent in the life review are relevant only for this group of experiencers. However, 4 of our patients reported negative experience, making this limitation less plausible. In any case, this applies only to the psychological factors related to the experience and not to more primary features such as perceptive ones.

In conclusion, the LRE may testify that a continuum of reflections on autobiographical memories exists in the human neurocognitive system (Saadon-Grosman, Tal, Itshayek, Amedi, & Arzy, 2015), manifested as LRE in extreme clinical cases. Further research in healthy people as well as patients with memory and other cognitive disorders shall expose the role of the system underlies LRE in health and disease.

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