

Cardiophenomenology: a refinement of neurophenomenology II – an experiential-empirical inquiry of the surprise reaction in depression with preliminary results

Abstract

Cardiophenomenology aims at extending, and partly reforming, the neuro-phenomenological approach of Francisco Varela, as a new paradigm on the joint-basis of Edmund Husserl's a priori conceptual dynamics of the living present (Husserl E; 1991) and an experiment of anticipatory time-dynamics of visual motor perception (Varela FJ; 1996). In order to do so, we situate this new paradigm at the cardio-vascular level of the emotional dynamics of the lived experience and thus refine the combining of the first- and third-person analysis. In a first 2019 article on "Cardiophenomenology: a refinement of neurophenomenology" (Depraz N, Desmidt T; 2019), we presented and argued for the theoretical hypothesis of cardiophenomenology, which centralizes the heart system as a core, intrinsic part of the cognitive system. The latter in turn needs to be enlarged in order to include a cardiac-affective dimension. In the present article, we aim to show how to do cardiophenomenology with the example of 4 participants, two with depression and two healthy controls, and we implement it by applying the core-hypothesis of Varela's co-generative methodology. We present preliminary results indicating how cardiophenomenology can be generatively applied, in this instance in the case of the surprise reaction of individuals with and without depression, who take part in an emotional task. This co-generative application of cardiophenomenology, its being effectively and fruitfully practiced, is as such a main result of the article 1. since neurophenomenology remains a speculative hypothesis, the applicability and practicability of which is still till now hardly demonstrated. Our additional goal 2. is also here to describe the psychopathological mechanisms underlying emotional reactivity in depression more accurately. In this regard, without going in detail into the results which will be presented in the article, we can observe that individuals with depression are not necessarily "hypo-reactive" to surprise as it is commonly stated in the psychopathological scientific literature, as in the case for melancholic, resp. catatonic states, but might be hyper-reactive with strong associated emotional rhythms, which may refer to another kind of depression named anxious depression. On the theoretical philosophical level proper finally, another result 3. concerns the very micro-dynamic of surprise during the emotional task: we argue here for an understanding of surprise non-limited to an abstract shock but encompassing the whole process of expectation and reaction after the shock. With such a global understanding in mind, we show the presence of gradual forms of cognitive mechanisms with continuities between the individuals undergoing depressive states and the ones who do not. This leads in turn to consider depression as being more multifaceted and more continuous with non-depressive states than initially thought.

Keywords: emotion, surprise, neurophenomenology, explicitation interview, microphenomenology, first-person method, third-person method, physiology, depression, heart system, clinical mechanisms

Natalie Depraz^{1,2}

Thomas Desmidt^{3,4}

- 1 Université de Rouen-Normandie (ERAC EA4307), Rouen, France
- 2 CNRS ENS, Archives-Husserl, Paris, France
- 3 CHRU de Tours, Tours, France
- 4 UMR 1253, IBrain, Université de Tours, Inserm, Tours, France

1. Introduction

Neurophenomenology was created by Francisco Varela [1] as a new paradigm on the joint-basis of Husserl's a priori conceptual dynamics of the living present and of an experiment of anticipatory time-dynamics of visual motor perception [2], [3]. Now, cardiophenomenology aims to extend, and partly reform, the neurophenomenological approach.

How? In a 2014 article, published in *Phenomenology and the Cognitive Sciences* [4], we described a model of temporal dynamic of emotional emergence with surprise as a core-phenomenon. In 2019, we subsequently presented and argued for the theoretical hypothesis of cardiophenomenology, which centralizes the heart system as a core and intrinsic part of the cognitive system [5], [6], [7]. The latter, in turn, needs to be enlarged in order to encompass a cardiac-affective dimension. We introduced, and discussed, four main theoretical arguments supporting the necessary inclusion of the heart system into the cognitive system. Beyond the crucial experiential attestation (we pre-consciously feel our heart beat), we analyzed a four-fold cognitive general argument:

1. the cognitive system is an extended bodily enactive system;
2. the cardiac system and the brain system function homologically in the cognitive system;
3. the embryo-genetic approach radically argues that the heart is the key system facilitating the growth of the organism, with the nervous system a consequence, not a principle; and
4. as an integrative argument, the brain, the heart, and the feeling-of-self, entertain reciprocal influences.

Finally, and as a consequence, we showed how cardiophenomenology, as a method using mutual generative constraints, is suited to refine and apply the neurophenomenological paradigm. As we argued, this direct methodological-pragmatic consequence as the actual operativity of the generative mutual constraints is based on the experiential-experimental strong continuity between lived bodily emotional experiences and organic physiological sensations, in contrast to the ontological heterogeneity between a priori phenomenological categories and the neuro-dynamics functioning unbeknownst to the subject still prevailing with neurophenomenology [5], [6]. We thus showed how neurophenomenology can be put to work and does not remain a speculative hypothesis. In order to do this, it is necessary to *apply* the core-hypothesis of mutual generative constraints. We showed how, remarkably, situating these constraints at the cardiovascular level of the emotional dynamics of lived experience is a relevant means to refine, concretize and effectuate the combination of the first- and third-person analysis.

In the present article, we now present preliminary results from four participants showing concretely how cardiophenomenology is generatively applied. We use the case example here of persons suffering from depression who

take part in an emotional task, of persons who do not, as a comparison.

2. The implementation of cardiophenomenology for the study of the physiology and psychopathology of depression

One of the aims of the Emphiline ANR Research Program was to characterize emotional reactivity in depression. We hypothesized that depression can be identified as an impairment in surprise and consists of a disorder of the temporality of emotional emergence.

The Emphiline Research Program was financed 2012–2015 by the french Agence Nationale de la Recherche (ANR) and is still ongoing. The theoretical methodological articles published 2014 and 2019 in PCS are encompassed in the whole Program, among other studies on surprise, emotions and depression published from 2012 onwards.

2.1. Depression

Depression is a frequent and severe disorder. Its diagnosis relies on clinical criteria including persistent deep sadness, loss of pleasure, sleep/concentration disorders and suicidal ideations. These criteria identified in the Diagnostic and Statistical Manual (DSM) are widely used but they have limitations, especially in clinical settings. In particular, the unique category of major depressive disorder can in fact refer to heterogeneous clinical presentations in the manuals. According to the DSM-V criteria indeed, more than 200 forms of depression can be identified depending on the criteria combination [8]. Thus many authors believe it is important to characterize further depression by accurately describing the psychopathology of patients. For example, there is growing literature about emotional disorders in depression [9], [10] but many inconsistencies remain, with emotional disturbances in depression remaining uncharacterized. Among the open questions we have here as one of our research questions is the kind of emotional reactivity of the persons suffering from depression: do patients with depression show a hypo-reactivity to pleasant stimuli and a hyper-reactivity to unpleasant ones [11]? Or are they rather characterized by a global hypo- or hyper-reactivity [10]? These questions are important to address insofar as depression in its standard form of severe depression is often only identified with a global hypo-reactivity to surprise. We intend here to nuance and differentiate this one-sided hypothesis.

In the Emphiline Research Program, we used the combined first-/third-person methodology of cardiophenomenology to also better characterize the lived experience and the physiology of participants with a remitted depression, but the results concerning these patients are reserved for later publications.

2.2. The method of the psychophysiological assessment

Seventy-five females aged 18–55 were recruited at the University Hospital of Tours.; the total sample encompassed 75 patients in three groups (n=25x3: (a) depressed patients (n=25): mean age 41.0 years (SD=12.6; range: 19–45), (b) remitted patients (n=25): mean age 42.9 years (SD=11.6; range: 21–47), and (c) controls (n=25): mean age 42.7 years (SD=13.0; range: 24–55). The subsample analyzed here consisted of four patients (mean age 38,5; range: 29 to 49), with the mean age of 38,0 in the group of depressed patients (two patients of 29 and 47), and the mean age of 39,0 the control group (two patients of 29 and 49); Participants received the diagnosis independently of this research, not within the recruitment.): depressed (D), if participants matched the DSM-IV criteria for major depression, control (C), if participants had no history of depression, and remission (R), if subjects had had at least one depressive episode but were currently in remission. Psychometric and clinical assessments were performed to characterize the intensity of depression (MADRS questionnaire), anxiety (STAI questionnaire), psychomotor retardation (RRS questionnaire), and the experience of pleasure and displeasure. For this research we then set up an original experimental protocol corresponding to an emotional task. Let us describe it concretely. A first stimulus (S1) was presented to the participants at the screen in front of them, namely a word corresponding to one of three categories of pictures: OBJECT, EROTIC, MUTILATION. 6 seconds later a picture (stimulus 2: S2) was presented to them, correlated to the word previously shown, namely a picture of a household object if the word OBJECT was shown before, of an erotic scene for the word EROTIC and of a bodily injury if the word MUTILATION was shown.

The choice of 36 pictures for the task was our original selection, based on our pre-tested expectation of them triggering various kinds of reaction of surprise and of associated emotions; besides, the choice of erotic and mutilations pictures was meant to bring a clear distinction between a positive and a negative valence, and to let the participants spontaneously describe the particular content of their emotional reactions in terms of its degree of intensity, its quality of arousal, or also of its being possibly unaffected.

We thus named this task a S1–S2 emotional task. The participants were comfortably seated and asked to look at the screen where the 36 emotional pictures (S2 from the International Affective Picture System: IAPS database; To maintain novelty and efficacy of the stimulus set, the IAPS images themselves are typically not shown in any media outlet or publications. The IAPS may be received and used upon request by members of recognized, degree-granting, academic, not-for-profit research or educational institutions [12]) of positive (erotic, n=12), negative (mutilations, n=12) and neutral (household objects, n=12) valence were shown for 6 seconds each. So the task un-

folded in three phases, anticipation (between S1 and S2), crisis (during the presentation of the picture=S2), aftermath (after it), each corresponding respectively to the 6 seconds between S1 and S2, the 6 seconds of the picture presentation and 30 seconds after the picture disappeared. The whole process of these three phases corresponded to what we identified as the dynamics of the surprise. In short, our S1–S2 emotional task was performed to identify and experientially explore these three phases of anticipation, crisis and aftermath.

Let us also indicate besides that the six last pictures out of the 36 and in contrast with the 30 first ones were paired: more precisely, they involved a mismatch between the cue S1 and the picture S2: for example, the word ‘mutilation’ (S1) was viewed and then a picture (S2) of neutral valence of a gold bar unexpectedly appeared (IAPS 3005.2 being a modified picture); then the word ‘mutilation’ (S1) was viewed and indeed a picture (S2) of a buried baby body appears (IAPS 3005.1 being the original picture). In other words, S1 would be mismatched with S2 for the 1st, 3rd, and 5th pictures, but congruent with S2 for the 2nd, 4th, and 6th pictures. With the building of this pairing-mismatch design for the last six pictures, we meant to possibly create a stronger reaction of surprise and associated emotions in the participants, due to the first counter-expectation experience and to the second confirmed expectation, and we may expect as an initial hypothesis the participants to choose these pictures as most striking (Table 1).

After each of these 6 last pictures and in order to identify a possible spontaneous reaction of surprise and emotions, participants were asked to react verbally, which some did with a high intensity through exclamations (“horrible!”), interjections (“wo!”), or with a silent reaction, which may also indicate sideration. Finally, we asked them to rate their arousal after each picture, on a 9-point Likert-scale.

Four types of physiological signals were recorded during the task: Heart Rate (HR), Respiratory Rate (RR), Skin Conductance (SC, i.e. an index of the peripheral nervous system activation), and ultrasound brain pulsatility (the data on brain pulsatility were not processed, hence these data are not discussed further here; an index of the cerebrovascular reactivity). We hypothesized that the amplitudes of the physiological signals would be lower in the participants with depression compared to the controls and the remitted participants, in the three phases. Finally, micro-phenomenological explicitation interviews were performed immediately after the emotional task.

To sum up, the S1–S2 emotional task described above was also meant to elicit surprise in particular, with a general hypothesis and research question as follows: contrary to what is commonly held, surprise would not be only a punctual reactive shock and stroke (πληγή: plêgê) [13], but it would belong to a whole dynamics made of three different phases inherent in the lived phenomenon of surprise, namely, beyond the “crisis” (phase 2), its “expectation” (phase 1) and its “aftermath” (phase 3). Furthermore, it would not be merely limited to an organic

Table 1: Time-diagram of two paired-mismatched pictures in the different phases

Phases	S1	Anticipation	S2Crisis	Aftermath	S1	Anticipation	S2Crisis	Aftermath
Time	2s	4s	6s	30s	2s	4s	6s	30s
Screen	Word	+	Picture 1	black	Word	+	Picture 2	black

Note: Each time the word is “mutilation”; here, picture 1 is a buried gold bar (IAPS 3005.2: the modified picture), picture 2 the buried baby body (IAPS 3005.1, the original picture); “black” is for black screen; + refers to the fixation cross during the anticipation phase, meant to focus attention.

emotion like anger, fear, disgust, sadness and enjoyment [14], but it would need a finer description involving its complex association with specific emotions (e.g. anxiety or quietness in the expectation phase; fear, disgust, joy in the crisis phase; relief, enduring anguish in the aftermath phase). In that respect, as we said, the pairing-mismatch design of the last six pictures was meant to possibly produce a higher, more salient and more contrasted dynamics of surprise in the participants.

The goal of the micro-phenomenological interviews as it is described in the following section is to retrieve the multiple lived experiences of these complex dynamics, the arising of different kinds of surprise, with their multifarious associated emotions according to the different phases of the dynamics.

2.3.1. The interview: general presentation and specific operativity in the Emphiline Research

Micro-phenomenological explicitation interviews [15], [16] aim at collecting the sequential moments of an individual’s lived experience by asking her to evoke, that is, to retrieve and come into contact with the moment that just happened, or that happened in a distant past. Using a non-inductive questioning with open “how”-questions (rather than “what” or “why” questions), the interviewer guides the individual in the micro-temporal unfolding of the specified moment and leads her to turn her attention to its pre-conscious dimensions: bodily (proprioceptive, kinæsthetic) sensations, duration and instant-like time, emotions, fluctuating diffuse states, internal images and flashes or associations linked to personal or intersubjective memories.

Thus the micro-phenomenological interview is an open non-directional interview as far as the singular content of the experience is concerned, even though it is directional as for the structure of the experience, but it is not a semi-directional one with a guide of questions. There is no necessary training for this format of interview (even though participants who already practiced this kind of interview may be able to grasp finer aspects of their experience), since the participant lets herself be guided by the open questions that are asked, which follow a quite codified and structured procedure. The idea is to let the lived experience emerge as it just occurred, here during the emotional task of facing a particular image that the patient has chosen herself as striking.

The micro-phenomenological explicitation interviews performed for the Emphiline Research were 20–30 minutes long (In a research study dealing with first-person data only, the interview may last longer, namely 40–60 min. In our study, we estimated that 20–30 min of interview would be sufficient, insofar as it occurred after a whole day at the hospital for the patients, through fMRI and the experimental emotional task.) and started with this instruction: “Among the 36 pictures you just saw, would you please choose a picture that was particularly striking for you?” We used this open instruction, because we wanted the participants to choose by themselves the picture they wished to describe, rather than suggesting one: indeed a self-chosen example is more likely to be directly available for recall, insofar as it implies that the subject paid explicit attention to it when viewing it. Before the actual interview, the interviewer informed the participants about the length of interview, the kind of questions asked, e.g., open ones, not specifying what was the theme of the research (emotions and a *fortiori* surprise) in order not to induce any pre-determined response. In our initial question, we therefore did not mention the word “surprise” or emotion-words to allow these dimensions to emerge spontaneously. The only thing the participants were informed about was that the research investigated about their first-person lived experience and whatever occurred (be it bodily, emotional, cognitive, imaginative, time- or the other-related) during the three moments or phases of the task, that is, at the moment when the chosen picture appeared on the screen as much as before and after.

In order to guide the participants, we used gentle and flexible questions to continuously support their wording. The specificity of our questions consisted namely in using again the very words used by the participants to describe what they experienced and help them expressing it further, thus sticking to what they actually lived. For example, a participant mentioned that during the expectation phase, she was peaceful enough. Then the question of the interviewer was: “so you are peaceful while awaiting the picture, would you describe to me how you are peaceful? Is there anything you do to be peaceful?” So the interviewer lets herself be guided by the wording of the participants along the unfolding of the different phases of the task, even if it means starting from the moment of the arising of the picture, then unfolding the aftermath phase when the picture disappeared and then coming back to the anticipation phase.

2.3.2. The method of analysis of the first-person data collected

Thanks to the interview, we were able to obtain 10–12 pages verbatim and about half of the lived description, when contextual information, comments, judgments and generalizations were left out.

As a whole, we performed 45 audio-recorded interviews, 15 *per* group: 1/5 of the participants chose sounds. Indeed we also have the participants listen to three sounds randomly before or after the pictures. These data were analyzed and presented in [17] (pp. 87–9); 4/5 of the pictures, were nearly always mutilations (more precisely, 9 chose sounds, 36 pictures and, 35 out of the 36, chose mutilation pictures. Only one chose an erotic picture, and none chose objects). Based on the transcribed interviews (the ‘verbatim’), N. D. set up a method of analysis in 4 steps.

Step 1

A ‘pre-analysis’ including 4 stages:

1. The transcription of the verbatim;
2. Direct and ongoing commentaries along the transcription;
3. A decoupling process, that is, distinguishing between the lived experience described and the “satellite information” extracted (context, judgments, commentaries, theoretical generalizations [15], [16] (pp. 43–52);
4. The extraction of the text presenting the lived experience alone.

Step 2

Step 2 was made up of the following two stages and was dedicated to the reorganization of the temporality of the experience in micro-phases. It is a delicate step, since it identifies the micro-phases that form the real timeline of the lived experience as having been decoupled from the timeline of the interview: so the stage 5 unfolded the main structured phases of the interview timeline, and stage 6. re-organized the timeline of the actual lived experience on the basis of the structured time of the interview. The possibility of refining the temporal micro-sequences (synchronic, diachronic, partial mappings, overlapping) depended upon the accuracy of this temporal reorganization.

Step 3

Step 3 corresponded to the analysis proper. During stage 7 we identified generative criteria as structural categories. 5 structural main categories were selected: 1. time, 2. language, 3. body, 4. emotion, and 5. cognition. They reflect the generic structure of the experience. How did we proceed concretely? We went through the textual micro-sequenced timeline of each interview and collected what referred in each to these 5 categories in order to produce

a first transversal synthesis. Stage 8 then produced a dynamical multifactorial scheme of the experience: during these stages four other categories were discovered and contributed to extend the initial model, e.g. 6. imagination, 7. moral emotions, 8. intersubjectivity (alterity), and 9. volition.

So the initial five dimensions of experience (stage 7) corresponded to generic a priori structures of any experience and served as first heuristic guides, as it was initially and exemplarily analyzed by Edmund Husserl in his phenomenological theory of experience [18], [19]. They were nuanced or modified when, for example, we discovered during the emotional task that one situation of surprise did not include cognition at all, as it occurred in our study in the case of the participant n° 1 (see, interview N. Depraz, 08/04/2013, Tours’ Hospital, Picture Mutilation. IAPS data base 3062 corresponding to a red-grey face) even though it remained instructive as an absent category of the experience.

In this regard, while phenomenology as a philosophy is an a priori approach and offers first generic structures of experience [18], for example, every experience occurs in time, time thus being a generic structure of experience, the fruitful impact of an experiential first person micro-phenomenological approach is to take empirical experiential data seriously, which may help us to discover new categories of the lived experience of surprise and associated emotions.

Step 4

Finally, during step 4, we named “constructive analysis” made of 3 stages, we built a reduced model of the three phases of the experience: 9. Crisis Phase (2), which is usually the first phase to be spontaneously explored by the participant, corresponding to the emergence of the potentially surprising image; 10. Anticipation Phase (1), and 11. Aftermath Phase (3). This model provided us with the final experiential-categorical framework to correlate with the physiological analysis presented in the above section (for the detailed presentation of method of analysis, see [17]).

In short, our study is phenomenological in two respects:

1. It relies on a philosophical structure of surprise articulated in a three-phased time-dynamic that unfolds the structure of time experience (anticipation/crisis/aftermath) and that we originally adapted while designing the research from Husserl’s time concept of the living present (retention/impression/protection) [18];
2. It relies on a micro-phenomenological approach with explicitation interviews, which allow refinement of the grain of experience and refer to *hic et nunc* moments, that are described as such, and renew phenomenology as a science of singular (not only generic) experiences.

3. Preliminary results with 4 participants: a co-generative coupling of first- and third-person approaches

We will now show and analyze preliminary results from the Emphiline Research Program based here on two participants suffering from depression and two participants without depression, that were obtained at the present stage of our research as a pilot analysis and before we complete the full data analysis.

Our conclusions regarding surprise, emotions and depression therefore are also preliminary, that is, to be confirmed and nuanced thank to the future complete analysis, since they are based on two particular experiential episodes, lived by two particular participants. Indeed there is a gap between examining one occurrence (for each participant) of hypo- or hyper-reactivity in relation to an occurrence of surprise, and making suggestions about the general form of their depression. Of course the gap may have been smaller if we were to examine a high number of such occurrences within one participant, but that was not what this study aimed at.

As we said, out of the 36 participants who chose a picture (the 9 other having chosen the sounds), 35 chose a mutilation picture, except for one who chose an erotic picture, and none chose the picture of an object. Out of these 35 participants, 12 chose the picture of a buried baby body (IAPS database, picture n° 3005.1), which corresponds to one of three mismatched pictures at the end of the series and, as we hypothesized, it may trigger stronger reactions. E.g. among these 12 participants, three were suffering from depression, four were remitted patients, and five were control participants. It makes this 'buried baby body group' our most numerous sub-group. Our 4 pilot-participants were then selected out of the 12. Here is again the time-diagram of the two pictures during the different phases (Table 1).

We decided to select participants with depression and without depression in order to possibly offer first a more contrasted view than what may happen with remitted participants. The latter indeed show more nuanced or ambiguous patterns and will be studied in a future research as a means to bring about a more complex analysis. Besides, we wished to have the same number of participants with and without depression in order to make the differences and similarities more striking. Concerning the participants with depression, the two we chose (out of the three who were available) offered striking contrasts regarding the kind of depression and their reactivity to the picture, while the third one appeared to us more ambiguous, given her explicit association with a possible PTSD. So we decided not to include it here at this stage. Concerning the participants without depression, we selected two as well in order to keep the balance and decided to focus at this stage on the two who offered the most detailed interview.

3.1. Third person data: psychometric assessments

Psychometric assessments (Table 2) show that control participant C30 (29 years old) exhibited no sign of depression, anhedonia, pleasure/displeasure hyper-reactivity, anxiety or psychomotor retardation. Control participant C27 (49 years old) showed no such signs either, but moderate anxiety (STAI=49/80), and a mild retardation (ERD=7/56).

The participant D05 (29 years old) suffered from moderate depressive symptoms (MADRS=29/60), and intense anxiety (STAI=62/80). She presented with a moderate psychomotor retardation (ERD=16/56), a moderate anhedonia, and a strong reactivity to unpleasant stimuli (score of displeasure=1.9/9). The participant D07 (45 years old) displayed a slightly more severe depression (MADRS=35/60), with intense anxiety (STAI=73/80), a moderate psychomotor retardation (ERD=18/56), and a marked anhedonia (score to pleasure=5.6/9). Finally, the two participants with depression mostly differ in their profile of pleasure/displeasure reactivity: D05 reported a high reactivity to displeasure, whereas D07 reported a low reactivity to pleasure.

3.2. First-person data

Although the crisis phase (phase 2) is the most richly documented and also the phase where the picture emerges and where the interview started, we present the three phases (anticipation, crisis, aftermath) in the continuous successive order of how the experience actually unfolded. Similarly, in the Figs. in the supplementary materials (Attachment 1, Attachment 2, Attachment 3), we reported the results in the successive order of the phases 1, 2, 3 in order to present a *systematic* view of the experiential dynamics of the surprise.

Let us enter now into the more detailed analyses of the EI of the four participants, starting with the control participants and then with the participants suffering from depression (Readers should refer to the supplementary materials in Attachment 3 for complete analyses and for color tables that provide a figurative analysis of the EI), with our three research questions in mind:

1. On the methodological level, we aim at showing the relevance of the operativity of cardiophenomenology as a generative combination of the first- and third-person approaches;
2. On the philosophical theoretical level, we investigate surprise and its associated emotions as a dynamics of three phases and not as a punctual shock limited to the mere reaction to the shown stimulus (here the picture). Hence, again, we explore the experience during the whole task and the three phases;
3. Finally, on the psychopathological level, we seek to provide a more nuanced view of depression than the standard hypo-reactivity to surprise commonly claimed.

Table 2: Psychometric assessment of 4 participants of the Emphiline Research

Participant	Age (y. o.)	MADRS /60	STAI /80	RRS /56	Pleasure score /9	Displeasure score /9
C27	49	4	49	7	8	2,5
C30	29	0	23	0	7	3,3
D05	29	29	62	16	7,5	1,9
D07	45	35	73	18	5,6	3,1

Note: MADRS: Montgomery-Asberg Depression Rating Scale; STAI: State-Trait Anxiety Inventory; RRS: Retardation Rating Scale

Let us notice that the form of depression that the two participants with depression are undergoing is only one among the many factors that could potentially shape the particular experience that, in these two particular cases, accompanied the viewing of this particular photo. Many factors can be included in how a particular experiential episode unfolds – from a participant being influenced by the demand characteristics of the experimental setting, through the fact that they are undergoing this task after the whole day of examinations at the hospital, their background orientation towards the task, the thoughts they might incidentally be experiencing, e.g. in relation to the previous picture, to the more or less random circumstance that they managed to read the word “mutilation” or not, or that they responded in some way to the instruction to react verbally.

3.2.1. Control Participants

General dynamic

The two control participants (C30/C27) showed similar dynamics with some variations:

- In the first place, a complex cognitive macro-process of the identification of the paired-mismatched pictures strategy;
- Second, a micro-process of surprise in two steps:
 1. immediate surprise right when viewing the picture: startle of disgust (C27), inner displeasure (C30);
 2. cognitive surprise: resolution of the enigma (C27) or surprise of understanding (C30);
- Third, crisis shows a similar sequential rhythm of visual emergence (2s), recognition (2s), and avoidance (2s) (C27), modulated in C30 as emergence (1s), visual avoidance (1s) and detailed recognition (4s).

For both control participants, anticipation (phase 1) is quite well documented, certainly because they easily identified the pairing-mismatch design of the 6 last pictures of the experiment. Unlike our two participants with depression, the two control participants detected the mismatch that generated a lived expectation (due to the cue S1: the word “mutilation”) that was thwarted (the picture of the gold bar had nothing to do with the announced word) and then fulfilled (the buried baby body picture indeed matched the word “mutilation”).

The control participants thus reported a general metacognition macro-process that we refer to as “the enigma solved”: it consisted of mentally coming back to the previous picture to compare the paired-pictures and find an explanation for the mismatch. Even though there was no mention of a “cognitive conflict”, participant C27 expressed a cognitive lack of “understanding” (which we named a “surprise of perplexity”), and participant C30 showed some marks of emotion, using the words “destabilized” and “being cheated” (which we named mixed emotional-cognitive). This process is summarized below in Table 3.

Participant C27

Anticipation (see Attachment 3, Fig. 3a)

So contrary to participants with depression (D05 and D07), anticipation was well described by participant C27. The phase 1 proper (6s) was precisely recalled: first she saw the word “mutilation” and was able to account for its properties (size, spatial situation), then she noticed the fixation cross; the initial focal vision of the word gave way to a layered cognitive, emotional (apprehension, displeasure) and inner discursive awaiting: “I am in alert”. Moreover, she was able to come back up to the anticipation of the previous picture (gold bar), but also to the crisis and its aftermath in a remarkable finely time-sequenced way.

Crisis (see Attachment 3, Fig. 3b)

Participant C27 reported a crisis composed of two sub-phases that included a quick perceptive sweeping when the picture appeared (sub-phase 2), and an avoiding of the picture (sub-phase 2'). She also reported a full and layered surprise immediately after the initial focal vision of the opened eyes of the buried baby body. So surprise was not limited to a startle of horror (D05) or even to an internal one (D07), as we will detail below with the two participants with depression: it was a motor-bodily startle and shiver, involving cognition (“it makes me face death”) and emotion (disgust intensified as revulsion): these three dimensions were integrated by the person herself in her very remarkable self-expression of a “startle of disgust”. The 3-layered surprise was then followed by a longer perceptive sweeping identifying other aspects (the color of the eyes, the buried position) and led to a wish of moving away from the picture (“unbearable”). Finally, the second focal vision of the “hand” triggered no more emotion (unlike D05 and D07 participants as we will see). Rather, participant C27 became aware of the link with

Table 3: C27-30 “The enigma solved”; detection of the mismatch design: a meta-cognitive macro-process of thwarted-fulfilled expectation

	Phase 1 extended Anticipation (30 s)	Phase 2 Crisis (6 s)
Time process	Expectation	Fulfillment
Cognitive process	No Understanding	Understanding
C27	“I don’t understand what you expect from me”	“It is the answer to the enigma before”
C30	“I did not really find a satisfying answer”	“It answers my questions”
Dynamics of the surprise	Surprise of perplexity	Surprise of the enigma solved
C27 (cognitive)	“I am surprised because it does not correspond to a mutilation”	“It surprises me”, “what I see as a tomb”
C30 (mixed: cognitive-emotional)	“A bit surprised, destabilized”	“That was the surprise, I was cheated”

the previous picture (comparison, association, recognition, reflective inner discourse) and finally identified the “solution of the enigma”, expressed as a second cognitive surprise.

Aftermath (see Attachment 3, Fig. 3c)

Regarding aftermath, participant C27 reported an inner persistence of the picture despite its physical disappearance: “it remains in my mind” (like D05, but with no bodily or heavy emotional confusion); then the word “react” was clearly noticed (unlike our two participants with depression) and triggered a verbal reaction: “it is disgusting”, which generated an actual sensation of disgust, identified as having been already present as a sensation during the vision of the picture. We have to do here with a complex and remarkable circular process of memory-reactivation that we referred to thanks to curved arrows on the Fig. 3c and that is absent in the participants with depression D5 and D7. A last quicker sub-phase accounts for bodily tension and a motor relaxing inner-discourse (again absent in our D5 and D7 participants).

Participant C30

Anticipation (see Attachment 3, Fig. 4a)

As for participant C27, anticipation in participant C30 was detailed, at least if we look at the extended anticipation process up to the gold bar picture. The anticipation proper (6s) was less well documented than C27; she did not see the word “mutilation”, so there was no emotional triggering of the awaiting state and a mere cognitive undetermined awaiting of the following picture: “I was only waiting for a picture that would have nothing to do with the previous one”. As for the extended anticipation, the vision of the gold bar and of the word “react” gave way to cognitive acts of surprise of “perplexity”, non-understanding, hypothesis, that were emotionally colored (surprise of destabilization, non-satisfaction, feeling of being cheated) and started the macro-process of “answering the enigma”.

Crisis (see Attachment 3, Fig. 4b)

The crisis of the C30 participant started with the now familiar immediate surprise two-steps micro-mechanism of a focal perception triggering emotion (here surprise of displeasure, internally expressed as “it’s horrible!”), followed by a synchronous kinæsthetic and inner-wish of

closing the eyes/avoiding the picture. The second sub-phase was longer and started with a perceptive sweeping, identifying a tomb with a baby, and opening the way for an intense cognitive process in micro-sequences. This process was generated by the recognition of a similar paired picture: comparison, understanding, triggering a surprise, answering the initial questioning, and opening up broader reflections.

Aftermath (see Attachment 3, Fig. 4c)

Regarding the aftermath, we found two sub-phases:

1. The participant let her imagination go (“I wander”) and her body relaxed, she also asked herself questions. The picture did not persist in her mind (unlike C27 or D05);
2. She saw the word “react” (like C27), but unlike C27, she did not understand why she would react (she did not know what to say) and ended up emotionally refusing to verbally react.

3.2.2. Participants with depression

For participants D5 and D7, anticipation (phase 1) was not documented. In fact, they recalled the previous picture (a buried gold bar) and its direct aftermath, which took place long before (30 s) the buried baby body picture, but the 6 s anticipation phase was not recalled at all. We, therefore, focused on crisis, well-documented in contrast, and added a few descriptive elements from aftermath.

Participant D05

Crisis (see Attachment 3, Fig. 5a)

Participant D05 reported an intense crisis made of a “cascade” of three surprises [20]:

1. a bodily startle-surprise,
2. an emotional shock of horror,
3. an inner surprise (emotional association).

Indeed, when the picture appeared, the focal view of the picture triggered a startle, an intense emotion of horror and tears came to her eyes (bodily surprise). In parallel, an inner association with her little brother emerged that triggered sadness and pity (emotional surprise). In short, the first phase of the crisis was made of intense bodily and emotional reactions, then internal associative emo-

tions. During the next sub-phase, participant D05 reported a perceptive sweeping of the picture and the emergence of a thought about dead people (“dead people need to rest in peace”), while background-emotions of sadness, empathy and pity persisted (“[the baby] is so small, I can’t do anything.”). Eventually, a new emotional peak arose from this dead people-thought, which continued with a moral collapsing feeling and a judgment about this “macabre” view. Thus, we have a crisis in form of three emerging surprises (motor-bodily, memory, thought) that are associated with different emotions. So surprise here was not reducible to a startle but it was multifaceted; neither was it an emotion by itself but it was immediately associated with an emotion (horror, pity, sadness). Moreover, emotions varied depending on the form of surprise and could be instant-like if linked to a startle or a thought, or more diffuse after an emotional associative surprise.

Aftermath (see Attachment 3, Fig. 5b)

The aftermath phase of participant D05 involved intense and long lasting bodily, cognitive and emotional experiences. She reported that the picture remained in her mind although it had disappeared from the screen: it mapped a high emotional persistence and a cognitive confusion even leading to an incorrect identification of the following picture.

During the interview, participant D05 identified as we said the two paired mismatched pictures, the gold bar and the buried baby body, but she mentioned as the following picture “a plate” (IAPS.7233). While checking the order of the pictures that were shown to her, we noticed that a different picture was shown to her, e.g., a person with white boots carrying apples (IAPS.2980). So we were able to detect a cognitive confusional state in the aftermath phase, maybe linked to her strong emotional trouble.

Participant D07

Crisis (see Attachment 3, Fig. 6a)

The crisis of patient D07 was also composed of two sub-phases starting by a quick perceptive sweeping, followed by a picture avoiding, which was absent in participant D05. Her initial reaction was not a startle, but an internal surprise including attention (“It struck me”), mixed emotion (non-understanding), and clear emotion (affection), whereas the peripheral view was associated with relational emotions (violence, hate) and symbolic associations about unhappy childhood as the patient reported discovering a person in the background, which resulted as a second surprise. The second sub-phase, a visual avoidance, was associated with a decrease in emotion, a sigh of relief and a wish for no more pictures, indicating stronger avoidance reactions in participant D07 than in participant D05.

Aftermath (see Attachment 3, Fig. 6b)

Given the visual avoidance posture in the last sub-phase of crisis, participant D07 did not report an aftermath influenced by the persistence of the picture but rather fo-

cused on the impression of suddenly discovering the black screen already being there. She then expressed an emotional ambivalence, a release mixed with a feeling of anger linked to the overflow of pictures.

3.3. Third person data: physiological assessments methodology and results

Physiological signals were recorded using the PowerLab AD instrument system that allows for a high spatio-temporal resolution and a perfect synchronization with the temporality of the stimuli presented to the participants. We extracted the curves of the signal (see Attachment 1, Fig. 1, for an example) of heart rate (HR), respiratory rate (RR), and skin conductance (SC) to empirically examine their variations. Each variation of the three curves was analyzed according to three criteria:

1. the variation direction (acceleration/deceleration),
2. the duration, and
3. the amplitude of the variations (beats per min for HR and RR, and micro S for SC).

We used HR variations as a reference to delineate sub-phases in the three temporal phases of emotional emergence, consistent with our model of cardiophenomenology and because HR reactivity is correlated with emotional or cognitive processes [21], [22], [23], [24], compared to SC, for which synchronicity in emotional tasks has been suspected [25]. Nevertheless, SC and RR are reliable markers to indicate a strong physiological reactivity, although their variations may be less accurately related to emotional or cognitive processes. Results for the physiological changes (HR, RR, and SC) are summarized in Table 4, Table 5, Table 6, and Attachment 2, Fig. 2a and Fig. 2b).

3.4. First-third person data comparisons

3.4.1. Method: a co-generative process based on Francisco Varela’s methodology of generative mutual constraints

To perform our first-/third-person data comparisons, we employed the following methodology. Let us indicate that, as a methodological pre-requirement, each analyzer was blinded for the initial analysis of the other dataset.

The innovative methodology we performed consisted in a co-interpretation of the first- and third-person analyses. To state it simply as a start, first-person data are known to be singular and specified data, that we want here to combine with third-person data. In order to do so, we relied on Francisco Varela co-generative methodology. What is its general claim? We have an analysis of first-person data on the one side and an analysis of third-person data on the other side. Francisco Varela’s contention is to consider that one analysis benefits from the other one and vice-versa: both enrich each other and thus provide a more complex understanding of our experience: he calls

Table 4: First-/third-person data within- and between-subjects comparisons, anticipation phase

Participants	Phase: ANTICIPATION			
	Sub-phases	2 s	4 s	
C27	HR	UP 6	UP 2	
	RR	FLAT	FLAT	
	SC	FLAT	FLAT	
	EI	Anticipation as a negative tension		
C30	Sub-phases	2 s	2 s	2 s
	HR	DW 10	UP 10	DW 5
	RR	FLAT	FLAT	FLAT
	SC	FLAT	FLAT	FLAT
	EI	Undetermined anticipation		
D05	Sub-phases	4 s	2 s	
	HR	UP 8	DW 8	
	RR	FLAT	PK 45	
	SC	FLAT	FLAT	
	EI	No Data		
D07	Sub-phases	4 s	2 s	
	HR	UP 10	DW 3	
	RR	PK 37	FLAT	
	SC	DW .3	UP 1	
	EI	No data		

Note: UP x indicates an acceleration of the signal of x units, DW y indicates a deceleration of the signal of y units, PK z indicates a peak of the signal with a maximum of z, FLAT indicates no change in the signal variation. HR: Heart Rate, RR: Respiratory Rate, SC: Skin Conductance, EI: Explicitation Interview

Table 5: First-/third-person data within- and between-subjects comparisons, crisis phase

Participants	Phase: CRISIS				
	Sub-phases	3 s	3 s		
C27	HR	UP 4	DW10		
	RR	PK 40	PK 35		
	SC	DW .6	UP 1.2		
	EI	Startle	Cognitive processes		
C30	Sub-phases	2 s	4 s		
	HR	UP 15	DW3		
	RR	PK 45	PK 33		
	SC	DW 0.3	UP 1		
	EI	Shock	Cognitive processes		
D05	Sub-phases	1 s	3 s	1 s	1 s
	HR	DW 4	UP 9	DW 5	UP 5
	RR	DW .5	DW 1.5	UP 2	UP 2
	SC	FLAT	FLAT	FLAT	FLAT
	EI	PER	Emotion	PER	Emotion
D07	Sub-phases	3 s	3 s		
	HR	UP 10	DW 10		
	RR	FLAT	FLAT		
	SC	FLAT	FLAT		
	EI	Emotion		Avoidance	

Note: UP x indicates an acceleration of the signal of x units, DW y indicates a deceleration of the signal of y units, PK z indicates a peak of the signal with a maximum of z, FLAT indicates no change in the signal variation, PER indicates a perceptive process. HR: Heart Rate, RR: Respiratory Rate, SC: Skin Conductance, EI: Explicitation Interview

Table 6: First-third-person data within- and between-subjects comparisons, aftermath phase

Participants	Phase: AFTERMATH			
	Sub-phases	4 s	2 s	14 s
C27	HR	FLAT	UP 6	DW 6
	RR	FLAT	FLAT	FLAT
	SC	DW 1	UP .8	DW .4
	EE	Avoidance	Disgust	Relaxation
C30	Sub-phases	4 s	5 s	11 s
	HR	UP 10	DW 25	DW 5
	RR	PK 30	FLAT	FLAT
	SC	DW .2	UP .2	FLAT
	EI	Relaxation	Opposition	Cognitive processes
D05	Sub-phases	10 s	10 s	
	HR	UP 15	DW 10	
	RR	PK 30	PK 70	
	SC	DWs/Ups	DWs/Ups	
	EI	Intense emotion	Persistent emotion	
D07	Sub-phases	2 s	18 s	
	HR	UP 10	DW 17	
	RR	PK 50	PK 40	
	SC	FLAT	FLAT	
	EI	Emotional ambivalence, relaxation		

Note: UP x indicates an acceleration of the signal of x units, DW y indicates a deceleration of the signal of y units, PK z indicates a peak of the signal with a maximum of z, FLAT indicates no change in the signal variation. HR: Heart Rate, RR: Respiratory Rate, SC: Skin Conductance, EI: Explication Interview

such a combined method a process of “co-validation”. In Varela’s view besides, this enrichment co-validation process requires a clear delimitation of the respective functions of each analysis, what he called their “mutual constraints”.

In the case of our emotional task and cardiovascular surprise dynamic research, the function of the analysis of the third-person data was to provide the fine and detailed *temporal framework* for the unfolding of the experience, based on HR variations. In this regard, the strength of the third-person data lied on the availability of objective markers that are accurate and that could be measured. On the other hand, the distinctive function of the analysis of the first-person data is to provide us with an interpretation, for example, sense-making of the third-person data (What is correlated with third-person data is not the initial verbatim of the participants, but the first-person data obtained after the analysis of the reports [17]). In this regard, the strength of the first-person data corresponded to the accuracy of the meaning, the multifarious categories a priori available and experientially emerging, and the fine micro-dynamic (sequentiality, partial mapping, overlapping, synchronicity) of the first-person description. Since the third-person data lacked specificity, as the same variations can be explained by opposed content-phenomena, such as an acceleration of the heart rhythm that may refer to an emotion of anxiety or of joy, the first-person data enabled us to clarify the specificity of the content. Since the objectivity of first-person data is nonetheless sometimes suspected because “holes” in the account

may appear, that is, aspects of the lived experience that may be available but were not consciously recalled at the moment of the interview, we sometimes will need to lead a second explication interview of the same experience in order to go deeper into it and detail it further.

We associated the two analyses and it helped to overcome their respective weaknesses, while benefiting from their strengths. Namely, the results of one analysis were able to confirm, to infirm, or to complete the results of the other, as well as to leave room for the possible emergence of new dimensions, like for example new categories that arose during the first-person analysis (alterity, imagination).

4. Results

The comparison of first- and third-person analyses are summarized in Table 4, Table 5, and Table 6, and in the Supplementary Materials (Attachment 2, Fig. 2a and Fig. 2b). These show both

1. consistencies between the first-/third-person analyses and
2. some relevant inconsistencies, which indicate the necessity to refine the analyses as a further step of our research (either by looking to additional physiological markers, like ultrasound brain pulsatility, or by performing a second more focused interview).

4.1 Anticipation

In addition to the anticipation phase proper (6 seconds between S1 and S2), our participants sometimes reported an “extended” anticipation that included the dynamic of the immediate previous picture.

4.1.1 In the 6 s anticipation phase proper

For C27, we found a consistency between an emotional tension and the continuous HR increase. The absence of RR and SC variations suggested a mild physiological tension; for C30, HR changes in three sub-phases and no change in SC and RR were consistent with the report of an undetermined anticipation and mild physiological tension; in contrast, D05 and D07 did not mention the anticipation phase proper even though they were explicitly invited to come back to what happened before the picture arose, which seems to indicate that they did not recall it.

4.1.2 In the 30 s extended anticipation phase

Although the participants with depression D05 and D07 described the previous picture (here the golden bar) and accounted for emotions in its aftermath, they did not indicate any cognitive waiting (a slight emotional ambivalence for D05). In contrast, our control participants C27 and C30 provided a detailed and finely sequenced description of what happened in the three phases of the previous neutral gold bar picture and contrasted it to the buried baby body picture. At the stage of our research, the third-person data corresponding to the extended anticipation are not available yet, but in further analyses, we plan to compare the third-person data in the previous dynamic and this report of an extended anticipation.

4.2 Crisis

The crisis phase was the most detailed one: it offered consistencies between first- and third-person data and revealed some forms of convergences e.g. continuities across D and C participants.

4.2.1 D participants

For D participants, crisis is segmented in two equally time-sequences (3 s/3 s), that is, the emergence of the picture and its duration.

For D05, each sub-phase was in turn sub-divided in perceptions and emotions, which matched quite well the four sub-phases of HR variations. Indeed, the brief initial HR deceleration matched the focal perception of the buried baby body and the subsequent acceleration matched a startle, a horror-emotion, cries and sadness. Then, the perceptive sweeping matched the HR deceleration and, finally, the emergence of moral emotions triggered by the thought about dead people matched the HR acceleration. While in the literature the association of HR deceleration and acceleration with, respectively,

cognitive and emotional processes remains a hypothesis [23] while being central [22], [24], these preliminary results seem to confirm that HR deceleration was observed when the participant perceived and thought (memory, judgment) whereas HR accelerated when the participant experienced emotions.

As for D07, she showed a different rhythm: no repeated fourfold alternation between perception-cognition and emotion, but simply a two sub-phased succession: an increasing strong emotionality, which matched the HR acceleration, and a deceleration which matched the decrease of emotional feeling linked to a visual avoidance, consistently with the decrease of the SC and RR.

4.2.2 Control participants

For the two control participants, the 6s time of the crisis was segmented in two unequal sub-phases: the initial four seconds referred for C27 to a focal vision, a startle of disgust and a perceptive sweeping, which perfectly matched the physiological rhythm of deceleration, acceleration and deceleration. The quicker second sub-phase (2 s) perpetuated the deceleration process with a visual avoidance (emotional decrease) (like the D07).

C30 also showed a specific rhythmic of crisis, with a quick first sub-phase (2 s), where a detailed vision led to an emotional wish of visual avoiding, which is consistent with a strong HR acceleration. The second longer sub-phase (4 s) indicated a clear continuous HR deceleration, which is paralleled by a detailed cognitive process of recognition and elaboration.

4.3 Aftermath

For C27, the description of three sub-phases as a memory-image process, a feeling of disgust and a final bodily relaxation was consistent with the initial lack of change in HR, the rapid HR increase, and the final HR progressive decrease, while SC indicated the presence of a persistent physiological reaction.

As for C30, she showed an initial HR increase, which seemed inconsistent with the report of initial relaxation and of cognitive processes. The subsequent HR decrease however matched the report of the refusal to react that involved an emotion of inner surprise of non-understanding and manipulation. This complex processual surprise that wove together volition and cognition may reveal the difficulty of establishing a too simple and too clear distinction between emotion (HR acceleration) and cognition (HR deceleration).

Indeed, acceleration and deceleration of the cardiac rhythm are processes: the distinction between both and, therefore, between emotion and cognition cannot be a clear-cut one. There are, however, different tendencies and stresses, some more emotional, some cognitive, depending on the intensity of the acceleration, and of the deceleration, and even possible temporal overlappings. Thus we encountered here degrees of intensity, and therefore degrees of emotional and cognitive processes,

that might sometimes merge into one another in some mixed emotions-cognitions, in our case, for example, of a surprise of perplexity (C27), or of a feeling of being cheated (understanding-manipulation) (C30).

D05 showed an adequate match between HR, RR, and SC and the intense bodily, cognitive, and emotional experience, attributable to the obsessive persistence of the picture, whereas D07 revealed an emotional ambivalence due to the visual avoidance that persisted in the aftermath: this emotional ambivalence corresponds to a rapid increase and to a final progressive decrease in HR-RR

5. Discussion

We presented here four preliminary results indicating how cardiophenomenology is generatively applied, e.g., based here on two participants suffering from depression and two participants without depression, that were obtained at the present stage of our research as a pilot analysis and before we complete the full data analysis of the 45 participants.

Of course, these results are based on analyzing two particular experiential episodes, lived by two particular participants. We are well aware that there is a big gap between examining one occurrence (for each participants) of hypo- or hyper-reactivity in relation to an occurrence of surprise, and making suggestions about the general form of their depression, and that the gap may have been smaller if we were to examine a high number of such occurrences within one participant, but that was not what this study aimed at.

As we said though, this sample of 4 participants is particularly exemplary, since they all chose the same paired mismatch pictures of the gold bar and of the buried baby body. The latter picture and the whole mismatch design proved to trigger strong reactions of surprise and associated emotions. It suggests that we will be able to rely on these first results to analyze the other ones. Furthermore, these case studies represent an important step in figuring out how to compare and cross-analyze first-/third-person data – an approach that we will then follow for all the other participants.

So we found that for control participants, the dynamic of emotional emergence was set in motion by the shock/physiological arousal of the crisis (initial shock/startle then cognitive elaborations associated with initial HR acceleration, then HR deceleration) that continues in the aftermath as a resonance until a relaxation phase (persistent feeling or avoidance strategy, then progressive decrease in physiological signals). In anticipation, we observed two different reactions: a tense anticipation associated with continuous HR acceleration and an undetermined anticipation associated with the classical three phases HR changes. The tense anticipation seems to be associated with a more intense HR deceleration in the crisis and more intense cognitive processes whereas the undetermined anticipation seems to be associated with a more intense HR acceleration in the crisis

and more intense emotional reactions. Thus, the level of arousal in anticipation may be negatively correlated with the level of reported a marked anhedonia and a global emotional hypo-reactivity. Nevertheless, other psychometric questionnaires seem not to be suitable to distinguish between the two participants, especially the anxiety (STAI) and retardation (ERD) scales. These preliminary results suggest the two participants underwent a different form of depression:

- The first is characterized by a hyper-reactivity of the dynamic of emotional emergence with a cascade of surprises, a strong reactivity in the aftermath (we could suggest that D05 exhibits a low resilience, understood as the capacity to adapt to crisis) and an intense physiological reactivity, especially cardiovascular;
- The second is characterized by a weak reactivity of the dynamic of emotional emergence, few reactions of surprises, a poor resonance in aftermath and low physiological reactivity.

This suggestion is consistent with the literature that argues for types of depression being preferentially associated with a global emotional hypo-reactivity and others with a hyper-reactivity to negative emotions [10], [11]. physiological arousal in the crisis and aftermath, and positively correlated with the level of cognitive processing. We found that our two participants suffering from depression exhibited two different dynamics of emotional emergence: D05 showed an intense emotional, physiological and cognitive reaction in crisis with a strong persistence in aftermath, whereas D07 showed a weaker emotional, physiological and cognitive reactivity. These results are consistent with the score from the questionnaires, as D05 reported a low anhedonia and a marked hyper-reactivity to unpleasant emotions whereas D07. In short, the discussion section shows congruencies between first-/third-person data and some incongruencies that we will address further.

6. Conclusion: summary and future directions

Cardiophenomenology proposes a refinement of neurophenomenology while providing a methodology for its practical implementation. In our study we put to work the two aspects of Francisco Varela's generative methodology: 1) the co-validation aspect revealed that the phases of crisis and aftermath show remarkable matches (confirmation/enrichment) of first- and third-person data; 2) the mutual constraints played an important part in our analysis as well, enabling to delimitate the distinctive functions of the first-person analysis (which offered detailed contents of the experience, unavailable in the third-person analysis) and of the third-person analysis (which provided us with the accurate timeline, unavailable in the first-person analysis); furthermore, the mutual constraints aspect was also useful in anticipation phase in particular, since gaps in the lived experience prevented correlations

with physiological data. This constraint suggested the importance of further interviews in order to focus on these gaps, in order to specify the anticipation phase, and an extraction of physiological data in order to validate the strong macro-cognitive strategy between anticipation and crisis for C-participants.

For what we can see so far, cardiophenomenology had three fruitful consequences for our research:

1. a methodological-epistemological one,
2. a practical-therapeutic one, and
3. a theoretical-philosophical one.

1. It attributes a central role to first-person data in the scientific research. Though sometimes considered unreliable, because particular, private and too qualitative in the literature, we aimed to show how they can be robust data in virtue of their temporal fine sequentiality, while mapping the third-person data; conversely, they enrich these third-person data remarkably, as far as the singularity of emotions and their content-meaning is concerned. In that respect, the Emphiline Research is a pilot-study which dynamically and rigorously correlates micro-phenomenological first-person data from a systematic novel analysis of interviews and third-person data from physiological signals;

2. This study was performed during an emotional task designed for an integrated understanding of the emotional reactivity in depression (for an earlier step dealing with epileptic seizures, see [26]) and the whole analysis of our data should allow for a better comprehension of its pathophysiology and psychopathology, to eventually optimize treatments. The reciprocal validation of micro-phenomenological explicitation interviews and some physiological measures may ultimately help to identify lived experiences that could reliably detect depression in participants at risk for somatic diseases, including cardiovascular ones, that are known to be highly prevalent in depression [27]. Some specific lived experiences identified by our interviews could then become reliable markers for the outcome of depression and could be used by clinicians to guide their treatment: for example, if the participant D05 is to develop a cardiovascular disease in relation to her hyper-reactivity to emotion, and if the latter is here associated with a lived persistence in the aftermath, it would be enough to identify such a disease in a clinical investigation in order to have a good lived marker of it without any necessary physiological measure and provide a fitting diagnosis; more broadly, it would be interesting as well as a further research to examine the implication of this new understanding of surprise for how we work with emotion and cognition in creative arts therapies [28], [29].

3. Finally, our study offers first insights into an innovative theory of surprise as a dynamic rather than as an instant-shock and compels revision of its definition as a mere emotion: a) surprise as a process is visible here in its recurrent micro-scheme vision-emotion and in its macro-cognitive mechanism of a thwarted-answered expectation; as we mentioned, such an understanding of surprise as

a dynamical process is based on a structure of surprise articulated in a three-phased time-dynamic that unfolds the structure of time experience (anticipation/crisis/aftermath). We originally adapted it while designing the research from Husserl's time concept of the living present (*lebendige Gegenwart*) as a model composed of retention (the just past moment), impression (the present moment) and protention (the moment about to come) [18]. Indeed, Husserl gives the primacy to the just past moment (retention) as a determined known moment, and considers protention (the moment about to come) as an indetermined uncertain moment. Given our stress on surprise and on its open awaiting as a key-moment of its dynamic, we decided unlike Husserl to underline "protention" ("awaiting, anticipation" in our terms) and to understand "retention" (in our terms, "aftermath") as a consequence of impression ("crisis") (more on this in [30], [31]). Besides, surprise as a phenomenon questions the too clear-cut distinction emotion-cognition while dynamically weaving them together into volition, but also into perplexity, manipulation or ambivalent processes (for more on this, see [17], [32], [33]). With these more complex emotions, we also want to show how micro-phenomenological first-person accounts bring about emotions that are not simply positive (joy) or negative (disgust), or only cognitive OR emotional, but psychic processes that include both positive and negative aspects (for example attraction-repulsion) and hence ambivalence, or that are beyond valence, like perplexity (for more details, see [34]). At this initial stage of cardiophenomenology the results of four participants are both encouraging and preliminary. They are based on analyzing four particular experiential episodes lived by four particular participants. We are well aware that there is a big gap between examining one occurrence (for each participant) of hypo- or hyperreactivity in relation to an occurrence of surprise, and making suggestions about the general form of their depression. In future studies, we aim to complete the analyses of the Emphiline study. It will allow us to bring about other important results based on the choice of the sounds that accompanied the experiment, and on the other pictures of mutilations chosen by the participants. In particular, we also aim to analyze the data of the participants with remission, who may provide us with still more nuanced and intermediate results, and complexify both our theory of surprise as a process and our understanding of depression. In the end, one challenge will be to identify invariants in the dynamic of the experience of surprise according to the participants' typology, and also to identify heterogeneities in depression forms.

Notes

Competing interests

The authors declare that they have no competing interests.

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NB: given the exposure to disturbing pictures, the experiment passed a board of ethics review at the CHRU in Tours.

Attachments

Available from <https://doi.org/10.3205/jat000026>

1. Attachment 1_jat000026.pdf (359 KB)
Supplementary Material 1
2. Attachment 2_jat000026.pdf (284 KB)
Supplementary Material 2
3. Attachment 3_jat000026.pdf (1120 KB)
Supplementary Material 3

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Corresponding author:

Natalie Depraz, PhD
pr.natalie.depraz@gmail.com

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