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What is the nature of the alteration of temporality in Trauma-Related Altered States of Consciousness? A neuro-phenomenological analysis☆,☆☆,★,★★

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ABSTRACT

According to the 4-D model of Frewen and Lanius, trauma-related altered states of consciousness (TRASC) involve an alteration of the dimension of time and memory which divides the symptoms of post traumatic stress disorder (PTSD) into those which occur in "Normal Waking Consciousness" (NWC) and those which present dissociative experiences as part of TRASC.

The present report addresses the temporal dimension of TRASC from a neurophenomenological approach. Initially, we generate an updated model of the structure of normal temporality. From there, we derive a model of altered temporality in TRASC, which at the same time indicates, from a theoretical point of view, which specific points of the structure of temporality would be altered in PTSD with TRASC. We pose two theoretical questions to guide our analysis: 1) What logical consequences can we derive from a graphic model of temporality in TRASC based on neurophenomenological analysis? and 2) Can altered chronesthesia be proposed as a phenomenon related with the dissociative disorders that affect how time is experienced in TRASC? **Material and methods**: To answer these questions, we carried out a systematic review of the literature up to May 2019, as well as a review of the classic philosophical texts that offer a view of temporality, with special emphasis on works in the field of phenomenology and neurophenomenology which offer graphic models of temporality. **Results:** We found 2671 articles associated with the keywords used in the search. Of these, 2603 articles were discarded based on a review of the titles and abstracts, leaving 68 reports that were reviewed in full text. We also reviewed classic philosophical texts dealing with the problem of temporality. From the results obtained we designed a scheme of normal temporality from which we derived a hypothesis as to how this variable would be altered in TRASC. The central point of the analysis explains under which hypothetical mechanisms the patient would lose his or her normal capacity to remember a past event or anticipate a future event, with the perspective that this would occur FROM the present moment. This would be an essential aspect of the alteration of temporality in PTSD with TRASC. **Discussion and conclusions:** We discuss the possible implications of our model for clinical practice, including non-pharmacological treatments. We then draw a correlation between the logical consequences of our model and the neurofunctional findings described in the literature. Finally, we offer answers to the two questions proposed, and to the central question of this report, stressing how altered chronesthesia could account for the alterations of temporality observed in PTSD with TRASC.

1. Introduction

The phenomena of psychic trauma, dissociation and temporality have found a common theoretical and clinical point in the concept of Trauma-related Altered States of Consciousness (TRASC) and the four-dimensional model (4-D model) recently proposed by Frewen and Lanius (Lanius, 2015). In their original report on the 4-D model, Frewen and Lanius conceptualised a theoretical framework for

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classifying the symptoms of post-traumatic stress disorder (PTSD) into those which may potentially occur in the context of "Normal Waking Consciousness" (NWC) and those characterised by dissociative experiences, in what is known as TRASC.

The 4-D model was developed on a philosophical-phenomenological basis (Thompson and Zahavi, 2007), and from neurophysiological studies of altered states of consciousness (Vaitl et al., 2005). Guided by the phenomenological tradition, the authors selected four dimensions of post-traumatic symptoms referring to the consciousness of: 1) time and memory, 2) thought, 3) body and 4) emotion. Each of these symptomatic dimensions is differentiated as to whether it occurs in NWC, or presents dissociative elements in the context of TRASC. For the temporal dimension, the authors make an important distinction between individuals who present phenomena of flashbacks/re-living as clinical expressions of the trauma, and those who present post-traumatic intrusive memories. The former would lose the capacity to live in the "now", re-living the trauma as if it were experienced in the present (thus indicating a dissociative phenomenon); the latter, in contrast, would remember the past from the now, without losing their temporal perspective (Lanius, 2015).

The present work proposes a hypothesis and general model of the possible mechanisms involved in the alterations of temporality present in TRASC, based principally on phenomenological and neurophenomenological methodology. Special emphasis will be placed on the design of a graphic model of altered temporality in TRASC and on relating this model of abnormal temporality with altered chronesthesia, reporting some clinical characteristics and neurophysiological findings in patients with PTSD with NWC and PTSD with TRASC.

1.1. Alterations of time in PTSD with TRASC and PTSD with NWC

1.1.1. Temporality in the healthy subject

Temporality in a healthy subject presents the following general characteristics: a) it is continuous (the flow of time is perceived as unfragmented); b) it has direction (it unfolds from the past towards the future); c) it presents a velocity that is experienced as stable and concordant with physical or chronometric time; d) the subject is able to distinguish spontaneously that what he/she remembers from the past or envisions for the future occurs in a present moment (mental time travel); e) it is possible to predict, within a given interval for each case, the physical time that has elapsed between two separate events. This concept is known today as the "temporal integration window" (TIW), which can vary from a few milliseconds for simple, unimodal information to several seconds for complex multimodal information. The prevalence of the TIW – lasting two to three seconds – across modalities, tasks, perception and production has led to the suggestion that it may reflect a general organizing principle of human cognition, better defined as the "subjective present", the phenomenal impression of "nowness", the "specious present" or the "field of presence" (Fairhall, Albi & Melcher, 2014).

If the above characteristics of temporality are not altered by a pathology, the consequence will be normal temporal consciousness. From the point of view of a subject's first person experience, this translates into a temporality experienced as stable and egosyntonic.

1.1.2. Alterations of temporality in PTSD with TRASC

The alterations of temporality that have been clinically described in TRASC, as part of a PTSD with dissociative elements, are multiple, and indicate theoretically that the phenomenon of dissociation presents numerous symptomatic clusters; psychopathological study of these clusters would improve the recognition of sub-types which could be addressed with differentiated treatments. This is the most important clinical and practical reason for deconstruction of the concept of dissociation (Bryant, 2007; R. Lanius, Brand, Vermetten, Frewen & Spiegel, 2012).

Among the alterations of temporality in TRASC we find: a) alterations in the continuity of temporality (fragmentation of temporality); b) alterations in the perception of the direction of time; c) alterations in the perception of the velocity of time (which may be perceived as faster, slower or stopped compared to chronometric time); d) alterations in the capacity to situate a traumatic episode from the perspective of present time (when this capacity is lost, the traumatic past is re-lived as if it were occurring in the present, and not remembered as a past event, in what is known as flashback); and e) alteration of chronesthesia or consciousness of temporality (Frewen & Lanius, 2015). Turning to alterations in the capacity for mental time travel, the prediction of chronometric time elapsed between two events and the presence of flashforwards, there is as yet no robust, unequivocal evidence that they represent a clinical specifier for PTSD with TRASC. Both clinical observation and the evidence conceptualise TRASC as a distinctive manifestation of PTSD with dissociative elements, implying greater clinical severity, more extensive manifestations in temporality and a higher probability of presenting early and repeated psychic traumas (Frewen & Lanius, 2015).

1.1.3. Alterations of temporality in PTSD with NWC

Alterations in temporality that occur in PTSD with NWC, or without dissociative characteristics, are less intense, and have a clinical impact on fewer of the characteristics of normal temporality mentioned above, compared to the alterations in temporality described in patients affected by PTSD with TRASC. Thus the features described in patients affected by PTSD with NWC are: absence of flashbacks (replaced by post-traumatic intrusive memories); normality in the continuity, direction and velocity of experienced temporality; presence of flashforwards (fear of future danger that may take the form of future-orientated mental images with sensory qualities that are vivid, compelling and detailed); and unaltered consciousness of temporality or chronesthesia (Engelhard et al., 2011; Holmes, Crane, Fennell & Williams, 2007). The clinical condition of these patients is therefore less severe than that of patients affected by PTSD with TRASC, whose traumatic experiences are probably not repetitive, nor did they occur early in the patient's life. For a summary of the characteristics of temporality in healthy subjects, patients with PTSD with TRASC and patients with PTSD with NWC see Table 1.

1.2. General, phenomenological and neurophenomenological approaches to the study of temporality

1.2.1. General approaches to the study of temporality

The most important non-philosophical contemporary works for understanding our approach to temporality are those of Norbert Wiener, Endel Tulving and David Ingvar. Norbert Wiener (Wiener, 1958) described a simple fact that is of fundamental importance: natural afferencies occur in "pulses"; this implies that if we perceived the impact of nature as constant and homogeneous, our ability to experience temporality would be enormously different. From this idea it may be deduced that sensorily perceived cadences, sequences and irregularities function as sorts of "temporal guides", especially if they fall into the indifference interval of two to three seconds in which they are interpreted as a single percept (TIW).

In 1985, Endel Tulving and David Ingvar took a decisive theoretical step, by relating conceptually the concepts of memory, temporality and consciousness. Ingvar proposed that it is impossible to plan the future without an episodic memory. Meanwhile, Tulving described the concept of chronesthesia to refer to a form of

Table 1
Characteristic features of temporality in healthy subjects, PTSD with TRASC and PTSD with NWC.

Characteristic of Temporality	Healthy Subject	PTSD with TRASC	PTSD with NWC
Continuity	NA	A	NA
Direction	NA	A	NA
Velocity	NA	A	NA
Mental Time Travel	NA	PA (no direct data available)	NA
Prediction of Chronometric Time	NA	PA (no direct data available)	NA
Presence of Flashbacks	NP	P	NP
Presence of Flashforwards	NP	PP (no direct data available)	PP
Chronesthesia	NA	A	NA

NA: Not altered; NP: Not present; A: Altered; PA: Possibly altered; PP: Possibly present; P: Present; PTSD: Post Traumatic Stress Disorder; TRASC: Trauma-Related Altered States of Consciousness; NWC: Normal Waking Consciousness. CC: Contemporary distinction between PTSD with TRASC versus PTSD with NWC.

consciousness that allows the individual to think about the subjective time in which he or she lives, and therefore enables him or her to travel mentally into a lived past or a possible future, a capacity known as "mental time travel" (Tulving, 1985;2002). The historical aspects of the philosophical and physical-chronometric study of lived time and temporality are fascinating, but they are outside the scope of the present report. The following bibliography is suggested for a more extensive review of these aspects (Brecher, 1932; Elliott & Giersch, 2015; Elliott, Shi & Sürer, 2007; Pöppel, 2004;2009; Nyberg et al., 2010a)

1.2.2. Classic phenomenological approaches to the study of temporality: The ideas of Edmund Hüsserl and martin Heidegger

Edmund Hüsserl's ideas on temporality:

One of the basic questions that Hüsserl seeks to answer in his writings on time and consciousness is: How can we be conscious of objects that present a temporal extent? and thence: How can we be conscious of objects like melodies, that cannot appear in a single instant but develop over time? Hüsserl's thesis is that the perception of a temporal object (and the perception of succession and change) would be impossible if consciousness simply gave us experience of the pure now-phase of the object, and if the stream of consciousness were a series of unconnected points of experiencing, like a string of pearls.

For Hüsserl, who probably made the greatest progress in understanding the structure of temporality from phenomenological analysis, "now" is not a temporal point or a thin line between the future and the just-past. On the contrary, he refers to "nowness" as a "temporal fringe" (Brough, 1991; Husserl, 1962); Merleau-Ponty reinforced this concept, calling this temporal space the "field of presence" (Merleau-Ponty, 2012). Thus, the "field of presence" or "specious present" (as William James named it), constitutes the context in which actions develop and where every event must be included to have a meaning in the actions of the subject (James, 1950). Both the most distant past and the uncertain future may become significant, in a present moment, since both are included in the immediate horizon of action.

Thus Hüsserl uses three technical terms to describe the structure of the temporal field mentioned above: 1) a "primal impression", which is the component of consciousness that is narrowly directed toward the now-phase of the object; 2) a "retention", which is the component that provides us with a consciousness of the just-elapsed phase of the object; and 3) a "protention", which is the component that intends the phase of the object about to occur. Thus consciousness involves the generation of a field of "lived presence". Although the content of consciousness changes, its structure in these three parts is maintained as a unified whole (Brough, 1991; Husserl, 1962). It is through retention and protention that consciousness extends beyond the now; and it is to this subtler dimension of the structure of temporality, or how objects appear to us as temporal, that Hüsserl refers as "consciousness of internal time", and later as "consciousness of the living-present" (Brough, 1991; Hüsserl, 1966).

The nature of lived time and its relation with the double intentionality of consciousness in Hüsserl's work.

For most classic authors, it appears clear that a central aspect of the experience of lived time is given by the spontaneous capacity with which we experience the flow of time as continuous and immutable, at the same as the objects of our experience are present with a precise temporal dimension. To understand this apparently contradictory process, Hüsserl describes the concept of "double-intentionality". This concept will be very important in our phenomenological evaluation of the alteration of temporality in TRASC. To express the concept more colloquially, double intentionality of the consciousness is the product of two simultaneous and non-deliberate processes, through which the subject can on the one hand experience the continuous, immutable flow of time (horizontal intentionality), and on the other adopt a position with respect to a past or future object of consciousness from a present temporal perspective (transverse intentionality) (Brough, 1991; Hüsserl, 1966). This double intentionality of the consciousness will allow us to remember a past temporal event, or think about a future one, conserving the notion that this mental activity occurs in the framework of a present temporal interval. The contemporary correlate of this phenomenon of double intentionality is known as mental time travel (Ingvar, 1985; Suddendorf & Corballis, 1997; Tulving, 1985). Hüsserl's diagram of the structure of temporality can be found in Fig. 1 (Letter a).

Martin Heidegger's ideas on temporality:

In his classic work "Being and Time", Heidegger made an important contribution to the phenomenology of temporality (Heidegger, 1962). As a general starting-point, the author states that the fundamental structure of the human being is "being-in-the-world". For Heidegger we are an event: not a sequence of events as in history, but a "*Dasein*", literally "there-being" as it is translated technically. In other words, how man exists in the world.

For Heidegger (1962), time is not just another entity, it is the basis of every human event. It gives unity to our existence and our whole being – our Dasein. When we exist, our existence develops in a spatio-temporal web. We are a past and a future, and this temporal "there-being" occurs phenomenologically in the first person as a unit with temporal continuity. The subject's perception is that he maintains a stable identity in his relationship with the world. Thus, Dasein is always entire; present with what it has been and will be, appearing as a whole. It is united by time.

A key point of Heidegger's view of the temporality of Dasein is that it always includes its "not yet". It implies a process of becoming, in which there is always an incomplete future, a might-be. Dasein is self-constituting as it unfolds in the world in its sequential relationship with other entities. The temporal character of Dasein depends therefore on how the subject relates with and discovers the entities in the world. On this point, Heidegger's approach comes close to Aristotele's conception that time "is change and amount of motion" (Rassi, 2014). This same concept, proposed by Heidegger, may be reformulated in contemporary language as follows: the temporal structure of Dasein is constituted from the correlations of co-determination *I–other–world* or *being–entity–world*, and the sequential manner in which those correlations reveal themselves and develop. As we see, Heidegger indirectly highlights the importance of the notions of circularity and co-determination, giving greater importance than did Hüsserl to the protentional or futural side of the subject. Thus, the world and its entities will be revealed as "temporal guides", as true

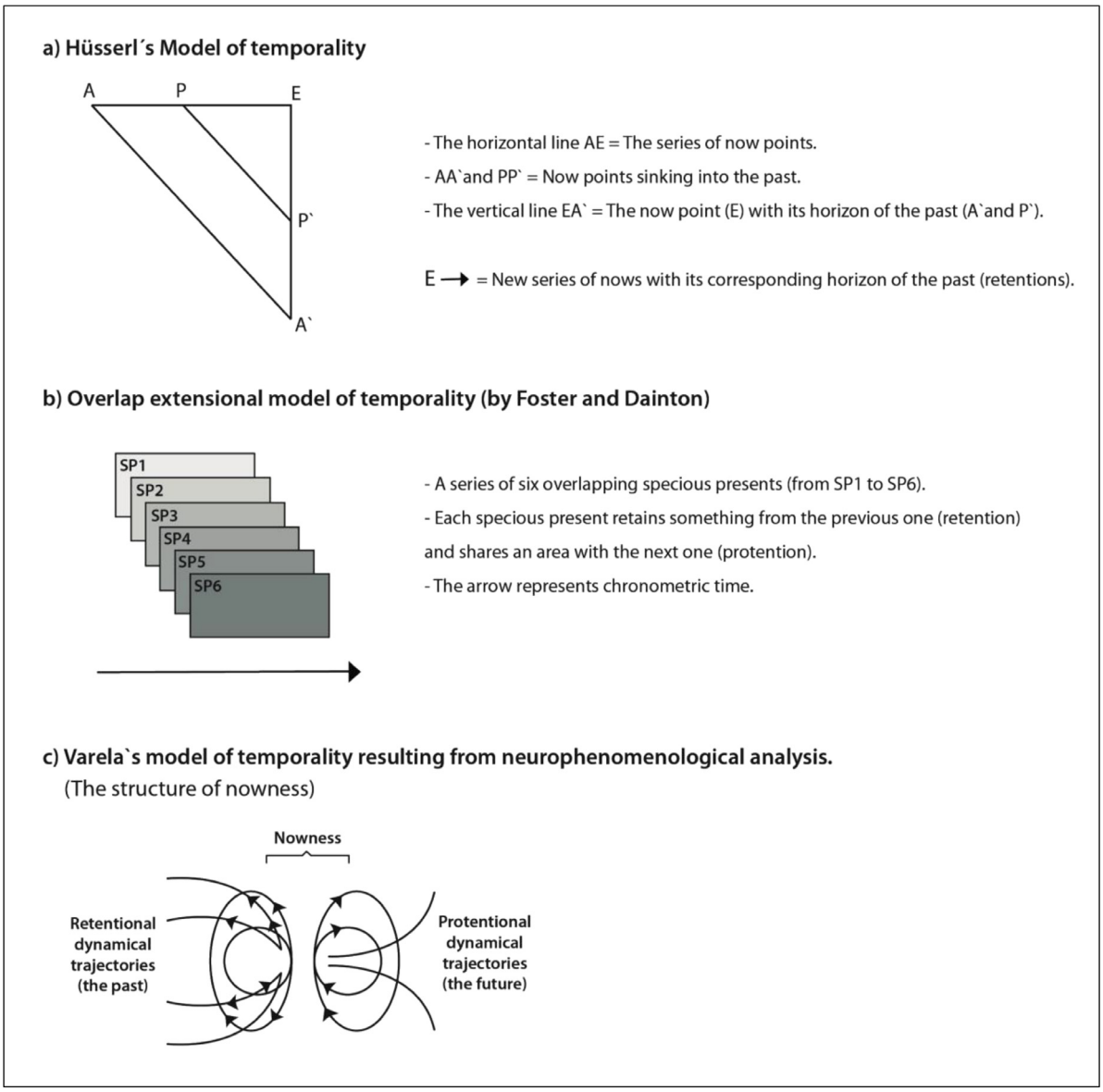

Fig. 1. Graphic models of normal temporality by Hüsserl, Foster & Dainton and Varela.a) Hüsserl's model of temporality: the horizontal line represents the advance of time. The sinking into pastness is depicted by the diagonal lines. Thus, in the progression of time from A to E, the time point A sinks down to point A' and the subsequent content P, sinks down to point P. In the vertical line EA' the time point E contains a retentional consciousness conformed by P' and A' (Adapted fromHüsserl, 1962; Hüsserl, 1966).; b) Overlap extensional model of temporality (Foster and Dainton): this model shows how each specious present (SP) shares a retentional phase and a protentional phase with the previous and subsequent SP respectively. The model represents graphically the seamless continuity our typical streams of consciousness exhibit (Adapted from Dainton, 2014). c) Varela's model of temporality: this model abandons linear geometrical representations like those proposed by Hüsserl, and opens up the theoretical possibility that in the micro-structure of temporality symmetry does not exist between retentions and protentions, since the latter unfold as an open horizon of anticipation – unlike retentions which are shown in his diagram as circular reentry flows. Nowness emerges from the reciprocal influence of retentional dynamical trajectories and protentional dynamical trajectories (Adapted from Varela, 1999).

patterns that – in the circular relationship of co-determination – give continuity or temporal stability to being (Brough, 1991; Hüsserl, 1966; Marks-Tarlow, Robertson & Combs, 2002).

1.2.3. Neurophenomenological approaches to the study of temporality

Francisco Varela's ideas on temporality:

The model proposed by Varela makes explicit that what emerges from phenomenological analysis of temporality is incompatible with a linear representation of the phenomenon, the view that we have received from traditional physics. This type of linear representation of temporality does not correspond naturally with extensive evidence from the cognitive neurociences that a minimum time exists which is necessary for the emergence of neural events correlated with cognitive events (Dennett & Kinsbourne, 1992). Thus Varela analyses temporality as a manifestation of large-scale cerebral integration, resulting in a "dynamical reconstruction" that forms the basis of his graphic model of normal temporality (Singer, 1993; Varela, 1995, 2001). Varela abandons linear geometrical models like those proposed by Hüsserl or Merleau-Ponty and opens up the theoretical possibility that in the micro-structure of temporality, symmetry does not exist between retentions and protentions, since the latter unfold as an open horizon of anticipation – unlike retentions which are shown in his diagram as circular reentry flows (Varela, 1999). Thus the process of neural synchrony correlates with experience, in this case temporality or lived time. Varela's diagram of the structure of nowness can be found in Fig. 1 (Letter c).

Varela's proposal is a central aspect of our model of normal temporality, since from it we extract the basis from which we schematise the micro-structure of "nowness".

1.2.4. The nature of the alteration of temporality in trauma-related altered states of consciousness: A new model

Our general hypothesis suggests that the central aspect of altered temporality in patients who present PTSD with TRASC is an alteration in the micro-structure of temporality which in turn determines altered chronoesthesia. Our object then, is to propose a graphic model of altered temporality in TRASC. We start by generating a graphic model of normal temporality based on knowledge of classic phenomenology and neurophenomenology, especially works that present visual proposals to facilitate conceptual understanding (Brough, 1991; Dainton, 2014; Hüsserl, 1966; Varela, 1999). Thus from a new graphic model of normal temporality we derive four possible points where the structure of temporality might be altered in TRASC.

The importance of this model of temporality is based on the fact that it allows us to understand better the dissociative symptomatology affecting temporality in PTSD with TRASC, as described by various authors (Brewin, 2015; Bryant, 2007; Lanius, 2015). It also provides a conceptual framework allowing better understanding of the therapeutic approaches used currently, based on the idea that important aspects of these therapies may be related with the capacity to act as "*interventions of temporal resynchronisation*", which would be a novel way of conceptualising these therapies. Thus, if our model is validated, it will be possible to propose new strategies tending to stabilise the alterations described in temporality in cases of PTSD with TRASC. From a general point of view, we propose that alterations in the micro-structure of temporality in TRASC are the principal reason why patients develop altered chronesthesia, lose the ability to re-live past traumatic events as a memory, and present alterations in the continuity, velocity and direction of lived time. Likewise these alterations could affect the capacity for mental time travel in this group of patients, as well as their capacity to predict the chronometric duration of external events. These considerations have been described partially and indirectly by various authors when discussing the relation between episodic memory, mental time travel, chronesthesia and clinical and neuro-functional findings in PTSD (Andelman, Hoofien, Goldberg, Aizenstein & Neufeld, 2010; Bluhm et al., 2009; DiGangi et al., 2016; Hassabis, Kumaran, Vann & Maguire, 2007; Hopper, Frewen, van der Kolk & Lanius, 2007; Ingvar, 1985; Lanius, 2015; Miller et al., 2017; Osuch et al., 2001; Suddendorf & Corballis, 1997; Tulving, 1985). However, we consider that an approach from the angle of the phenomenology and neurophenomenology of temporality could help to improve the integration of these findings. The central question of this report is "What is the nature of the alteration of temporality in Trauma-Related Altered States of Consciousness?". To make it easier to answer this question, we propose two questions which we answer from an analysis of classic and contemporary literature:

First question: What logical consequences can we derive from a graphic model of temporality in TRASC based on neurophenomenological analysis?

To answer this question we made a systematic analysis of the phenomenological and neurophenomenological literature. With this information we generated a new model of normal temporality based on the works of B. Dainton and F. Varela, from which we can derive a graphic model of altered temporality in TRASC (Dainton, 2000; Varela, 1999). The transition between the new model of normal temporality and the model of altered temporality under pathological conditions is achieved by identifying the possible points or regions in which the micro-structure of normal temporality could be altered. In this way we seek to correlate the logical consequences of our model with the clinical alterations described in TRASC, and with the neurobiological alterations described in PTSD with TRASC and in chronesthesia. Although our model for normal temporality is based on two contemporary authors (Dainton, 2000; Varela, 1999), it also takes up many concepts of classic phenomenology, allowing the generation of a conceptually more robust and descriptive theoretical construct (Brough, 1991; Heidegger, 1962; Hüsserl, 1966; James, 1950; Mensch, 2014; Merleau-Ponty, 2012).

Second question: Can altered chronesthesia be proposed as a phenomenon related with the dissociative disorders that affect how time is experienced in TRASC?

The clinical alterations described in PTSD with TRASC share some of the characteristics reported in substance-induced altered states of consciousness. These include altered temporality and experiences related with the sense of self, such as depersonalisation and derealisation (Preller & Vollenweider, 2018; Sanz, Zamberlan, Erowid, Erowid & Tagliazucchi, 2018; Yanakieva et al., 2019). On the other hand theoretical studies on the constitution of consciousness describe temporality as a basic component. It can be expressed auto-reflexively in what is known as autonoetic consciousness, associated with episodic memory, but it can also be experienced directly and pre-verbally in what is called anoetic or pre-noetic consciousness (LeDoux & Lau, 2020; Tulving, 2004;2005; Vandekerckhove & Panksepp, 2009;2011). Both arguments, one experimental and the other conceptual, suggest that chronesthesia altered by trauma may be related with the dissociative experiences in temporality described in PTSD with TRASC. Our report proposes that psychic trauma alters the structure of normal temporality, which – as a constituent part of consciousness – would determine altered chronesthesia. Both alterations (in the structure of temporality and in chronesthesia) would be related with the dissociative experiences in temporality typical of PTSD with TRASC.

To answer this question, a non-systematic review was carried out of the bibliographical evidence that connects the neurobiological alterations present in PTSD with TRASC with the neurobiological correlates for chronesthesia. We then made the pre-supposition that if two phenomena present similar neurobiological correlates, a relation must exist between them even if it is not necessarily possible to establish a relation of causality or directionality. Thus if similar neurobiological findings occur between PTSD with TRASC and the biological bases for chronesthesia, we can answer the second question in the affirmative.

Many reports indicate that the areas of the brain involved in the neural substrate of cronesthesia and mental time travel present an enormous similarity with the regions altered in individuals who have suffered psychic traumas and are symptomatic, especially from the angles of alterations of memory, perception of time and dissociative phenomena. The neural regions and networks which have been reported to be affected by alterations of chronesthesia, mental time travel and psychic trauma are: corticothalamic networks, hippocampus (especially region CA3), frontoparietal networks and alterations in the connectivity between the default mode network and the medial temporal lobe (Andelman et al., 2010; Botzung, Denkova & Manning, 2008; Eichenbaum, 2013; Karl et al., 2006; S. B. Klein, Loftus & Kihlstrom, 2002; L. Nyberg, Kim, Habib, Levine & Tulving, 2010; Okuda et al., 2003; Smith, 2005). Furthermore, a role has been described of the anterior insula both in the capacity to be conscious of the present moment, and in the physiopathology of traumatic phenomena associated with alterations of temporality such as flashbacks and re-living experiences (Craig, 2009; Hopper et al., 2007; Whalley et al., 2013).

We therefore propose to adopt a neurophenomenological posture to enrich conceptually the aspect of the 4-D model that refers to temporality, as well as to provide better understanding of the clinical phenomena present in TRASC and the possible action mechanisms underlying different therapeutic approaches.

2. Material and methods

Methodology

2.1. Phenomenological and Neurophenomenological analysis

We carried out a search and review of the classic phenomenological works referring to temporality and consciousness. To ensure appropriate selection of texts, we first did a systematic search in PubMed of all the articles published in English up to May 2019 using the following keywords and combinations of words: "temporality", "phenomenology AND time", "phenomenology AND temporality", "temporality AND consciousness", "PTSD AND TRASC" and "neurophenomenology AND temporality". Then one of the authors (CR) reviewed the abstracts to select the reports relevant to our study. The bibliographies of the selected works were searched to find the original sources of classic texts and authors. Finally an in-depth review was carried out of the work of those authors who propose schemes of temporality, as this would be of special interest in the formulation of a graphic model which would help us to answer the questions proposed in Section 1.2.4. This longer analysis was carried out by all three authors.

2.2. Procedure for bibliographic selection

2.2.1. Criteria for selecting reports from the keywords used

Once the results of the initial bibliographic search had been obtained, the reports were selected if they met one of the two following criteria:

1- The title and/or abstract indicated that the report referred to the phenomenology or neurophenomenology of normal temporality.
2- The title and/or abstract indicated that the report referred to the phenomenology or neurophenomenology of altered states of temporal consciousness in PTSD.

2.2.2. Criteria for the selection of classic phenomenological texts

The texts of classic phenomenology were extracted from the citations found in the bibliographic search carried out previously, as described in Section 2.2.1. The criterion used for selecting these texts was that they complied with point 3 below and at least one of points 1 and 2:

1- The text refers explicitly to the relation between temporality and consciousness.
2- The text presents a graphic model of normal temporality from which ideas could be extracted for the drafting of a new proposal that would serve as a basis for a model of altered temporality in PTSD with TRASC.
3- At least one English translation of the original text exists.

2.2.3. Criteria for the selection of contemporary neurophenomenological reports

Contemporary neurophenomenological reports were selected on the basis that they complied with one of the following criteria:

1- The report presents a graphic model of normal temporality.
2- The author of the report bases his/her work on the research proposal known as neurophenomenology.

2.2.4. Criteria for the selection of reports with relevant neurobiological information

Neurobiological reports were selected if they complied with one of the following criteria:

1- The report refers to the neurophysiological correlates of chronesthesia.
2- The report refers to the neurophysiological correlates of PTSD with TRASC.
3- The report refers to the neurophysiological correlates of PTSD with NWC.

On this point, non-systematic searches in PubMed and from reports and textbooks already known by the authors were carried out subsequently to explore further or understand better the neurobiology involved in chronesthesia, PTSD with TRASC and PTSD with NWC.

2.3. Results of the bibliographic search

The bibliographic review found a total of 2671 articles associated with the keywords entered. Of these, 2603 articles were discarded based on a review of the titles and abstracts, leaving 68 reports that were reviewed in full text. From the citations in these 68 reports, we selected three authors whose work fits into the current of classic phenomenology, and whose seminal texts comply with the three criteria mentioned in the previous section. These authors were: 1) Edmund Hüsserl (Brough, 1991; Hüsserl, 1966), 2) Martin Heidegger (Heidegger, 1962) and 3) Maurice Merleau-Ponty (Merleau-Ponty, 2012). Finally, two contemporary authors were selected on the basis of the criteria mentioned above: 1) Francisco Varela (Varela, 1999) and 2) Barry Dainton (2008Dainton, 2008,B. 2010a,B. 2010b). Due to the complexity of the subject, we encountered some difficulties in understanding certain concepts, or the need to explore a specific aspect in greater depth, during our review of the work of these classic and contemporary authors. In both cases we used the same methodology: first we made a further review of the 68 reports initially selected with this specific object; if we did not find sufficient information, we carried out non-systematic bibliographic searches which were added to the references.

At the end of the process described above (2.2.1, 2.2.2, 2.2.3 and 2.2.4), the total number of references reviewed in full text were 156. These references included: the 68 original articles from the systematic review, including 2 reports on neurophenomenology (Varela's work), 2 reports from a contemporary author that included a graphic model of normal temporality (Dainton's work) and 6 non-philosophical contemporary reports related to temporality (Tulving=4, Ingvar=1 and Wiener=1). Besides, 4 seminal texts on phenomenology were reviewed (Hüsserl=2, Heidegger=1 and Merleau-Ponty=1). Finally, 84 references (reports and textbooks) correspond to non-systematic searches as was already explained in Section 2.2.4.

The complete text selection process is shown in the flowchart (Fig. 2).

In this way an original model of temporality in trauma was constructed, based on both traditional phenomenological sources and contemporary neurophenomenological works. This model was used to derive logical consequences, which will be presented as part of our theoretical response to the questions formulated.

3. Results

3.1. Classic and contemporary graphic models for the structure of normal temporality

After reviewing the works and publications of both classic and contemporary authors on the phenomenology and neurophenomenology of temporality, we found four authors who propose graphic models to approach the phenomenon; we took these as the basis for the construction of our own model of temporality and how it is affected in TRASC. For a summary of the graphic models of temporality that served as the basis for our model, see Fig. 1. Merleau-Ponty's graphic model has been excluded intentionally from this figure, as it presents only minor differences from Hüsserl's.

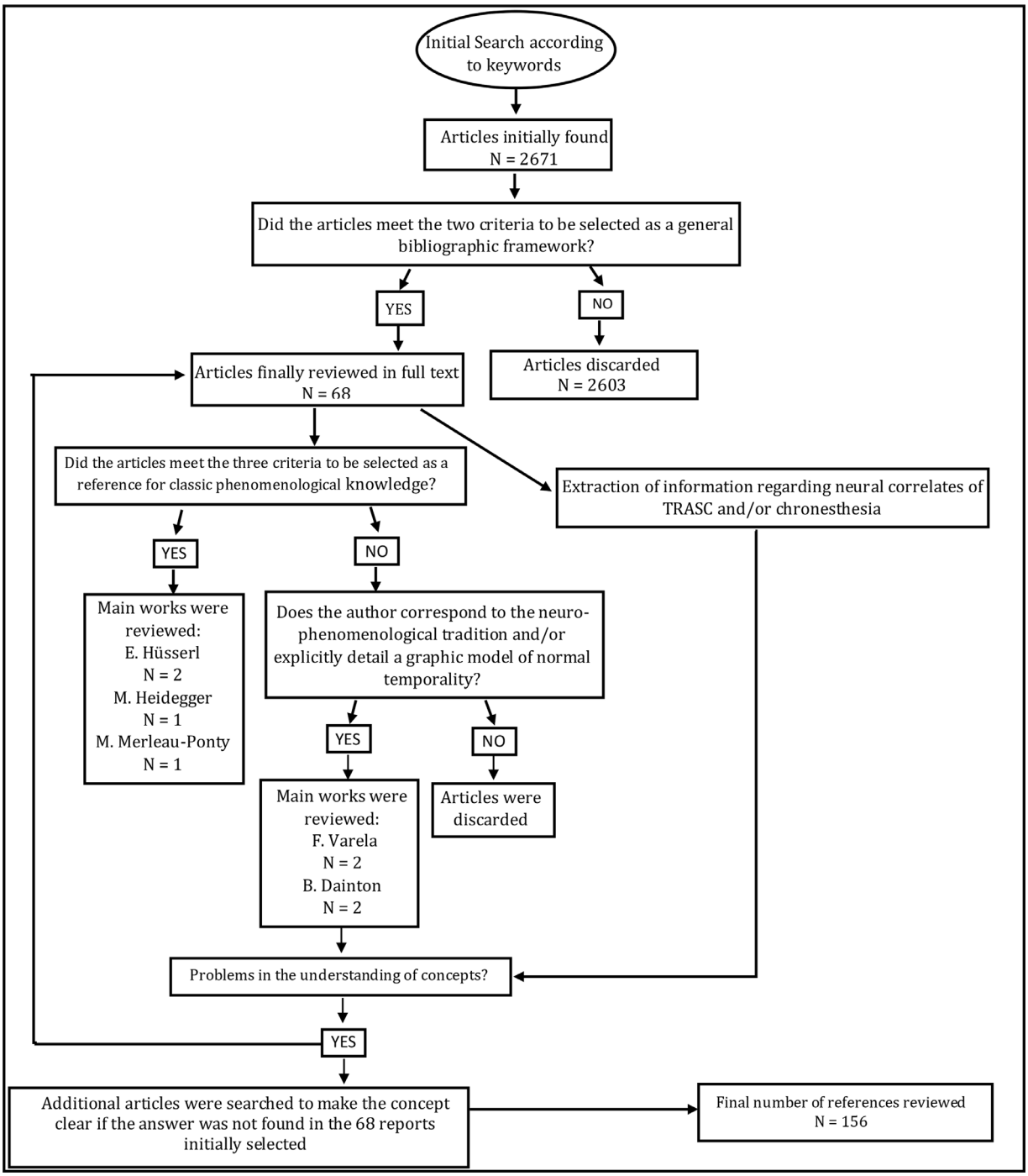

Fig. 2. Flowchart of the selection of authors, main seminal works and reports included in the present report.

3.2. Design of the graphic models of normal temporality and altered temporality in TRASC

3.2.1. Basic steps for the construction of a graphic model of normal temporality

The following series of steps was developed to construct our model of normal temporality:

1 The model was constructed using the graphic representation of nowness as its starting point and initial reference. The contemporary evidence indicates that nowness has a chronometric duration recognised conceptually by both Hüsserl and James (Brough, 1991; Hüsserl, 1966; James, 1950). It was therefore represented in the diagram as a rectangular area, based on the “overlap extensional model” (2008Dainton, 2008,B. 2010a,B. 2010b); the nomeclature "specious present" was adopted to identify it.

2 The following steps were included in the construction of the model, in consideration of the characteristics of normal temporality mentioned above: continuity, velocity, direction, the ability to carry out the function of mental time travel, the ability to predict chronometric time and the emergence of a consciousness of temporality (Table 1).

3 Continuity: given that normal temporality is lived as a continuum (unfragmented), we decided to draw this property as in B. Dainton's model, which highlights the superposition of specious presents (Dainton, 2014) (Fig. 1, Letter b).

4 Velocity and direction: the ability to experience temporality with a stable velocity, also concordant with chronometric time, and the characteristic of normal temporality of having a precise direction (it is experienced from the past towards the future), decided us to construct the model so as to contrast lived time or temporality with the notion of chronometric or physical time, which is represented by a unidirectional arrow.
5 The function of mental time travel: considering the empirical demonstration that one of the normal functions of temporality in a healthy subject is his/her ability to remember the past or anticipate the future from now, and that this is altered in PTSD or in patients with neurological damage classically described in PTSD (for example damage to the hippocampus), we decided to include this aspect graphically (Andelman et al., 2010; Zlomuzica et al., 2018). To stress the idea that this function is carried out with evident consideration of chronometric time, since this phenomenon is defined by recognition of the fact that the subject "travels in time from the physical present", we decided to represent this characteristic as a line running parallel to chronometric time.
6 The emergence of consciousness of temporality: since it proved impossible to include this variable in the model of normal temporality, it was included in what we call the "Model of temporal guides" (enactive chronesthesia), using a different diagram (Fig. 5). This quality of temporality is dicussed in Section 3.4.
7 The micro-structure of nowness: to complete our model, we included a graphic element to reflect the intimate structure of nowness. For this we used the graphic model of F. Varela (modifying one of its aspects). We decided to use this model because the dynamic flows present in a relation of co-determination – representing the protention and retention described by Hüsserl (Brough, 1991; Hüsserl, 1966) – better describe the relation of interdependence found between the experience of the immediate past and the notion of a future that has yet to occur (Varela, 1999).

For a more structured description of the line of thought used for the construction of our model of normal temporality, refer to Table 2.

Two aspects which form part of the neurophenomenological approach are: 1) the importance acquired by first-person approaches; and 2) the importance of circulation between the external and the experiential. Thus, as initially pronounced to be a central aspect of this methodology: "Phenomenological accounts of the structure of experience and their counterparts in cognitive science relate to each through reciprocal constraints" (Varela, 1996). Our analysis of the structure of normal temporality arises not only from analysis of bibliographic sources, but also incorporates our systematic observation of first-person experience of this phenomenon. In the Discussion we will review the neurophysiological alterations associated with each logical consequence derived from the model of altered temporality, not with the object of proving our proposal, which is not the purpose of this report, but to establish possible correlations for later analysis.

3.2.2. Basic steps for the construction of a graphic model of altered temporality in TRASC

To create a theoretical model of altered temporality in PTSD with TRASC, we searched the areas or regions of the graphic model of normal temporality in which, according to intuitive and logical analysis, alterations might be found. The starting points from which to find

Table 2
Novel graphical aspects in our current model as contrasted with the classical components of normal temporality. .

TIW: Temporal Integration Window. Characteristic of Normal Temporality	Main Phenomenological Features	Ideas Adopted from Previous Graphic Models	Graphic Representation on the New Model
Constitution of Now (Nowness)	- Nowness is a temporal fringe, not a thin line between future and past. - Nowness can also be named as "specious present" (James, 1950) - Nowness has a chronometric duration lasting 2–3 s (TIW) (Fairhall et al., 2014).	- "Overlap Extensional Model". (Dainton, 2000, 2014; Foster, 1979).	- Nowness was represented as rectangular areas.
Continuity	- Normal temporality is lived as a continuous flow (Hüsserl, 1962; Frewen & Lanius, 2015; Heidegger, 1962).	- "Overlap Extensional Model". (Dainton, 2000, 2014; Foster, 1979).	- Continuity was represented as superposition of rectangular areas (Nowness or specious present).
Velocity/Direction	- Temporality has a stable velocity and presents a correlation with chronometric time. - Temporality is an unidirectional experience (from past to future) (Frewen & Lanius, , 2015).	- Hüsserl's basic model of temporality (Hüsserl, 1966; Mensch, 2014)	- Velocity and direction were represented as a unidirectional arrow. The arrow represents chronometric time and its relation with temporality (For example through the concept of TIW).
Mental Time Travel	- Capacity to travel mentally into a lived past or a possible future. (Ingvar, , 1985; Tulving, 1985).	- No previous model was used.	- Mental Time Travel was represented by a line situated parallel to chronometric time. Its point of reference is contained inside of nowness and represented as a red dot.
Chronesthesia	- Form of consciousness that allows the subject to think about the subjective time in which he or she lives. Hüsserl used the concept of "consciousness of internal time" (Brough, 1991; Tulving, 1985).	- No previous model was used.	- Concept not included in the model of normal temporality. - Concept included in our model of temporal guides or enactive chronesthesia.
Micro-Structure of Nowness	- Nowness has an intimate structure related to the relation of retention and protention (Hüsserl, 1962; Mensch, 2014). Nowness emerges from co-determination between dynamic flows of retention and protention (Varela, 1999).	- Varela's model of temporality.	- Nowness emerges from dynamic circles of co-determination of retention and protention, represented as two circumferences each containing two arrows pointing in the same direction.

these regions with probable alterations were the clinical manifestations of altered temporality in patients suffering PTSD with TRASC, and the characteristics of the constitution of nowness and mental time travel.

We have said that we used logical, intuitive analysis to design our model of altered temporality in PTSD with TRASC, based on the model for normal temporality. Below we explain what we mean by "intuitive analysis". One of the principal aspects of neurophenomenology as a research programme is that it validates intuition or "intimacy" as a way of generating possible responses from findings in the practice of what is known as "phenomenological reduction" or "bracketing" of the phenomenon studied. On the other hand, we consider that it is valid to use diagrams or visual models to transmit the possibilities identified intuitively. As Varela says: "If intimacy or immediacy is the beginning of this process, it continues by a cultivation of imaginary variations, considering in the virtual space of mind multiple possibilities of the phenomenon as it appears. These ideal variations are familiar to us from mathematics, but here they are put into the service of whatever becomes the focus of our analysis, for example the structure of nowness", adapted from Varela (1996). And later: "The next component is as crucial as the preceding ones: the gain in intuitive evidence must be inscribed or translated into communicable items, usually through language or other symbolic inscriptions (think of sketches or formulae)" (Varela, 1996).

This is what we have done in the transition from our model of normal temporality to the model of altered temporality in TRASC: the search for possible solutions that emerge from intuition or "intimacy" which we then communicate visually. This is the basis for a theoretical model of PTSD with TRASC. Here we must clarify that the word intuition or "intimacy" is not a notion that must be understood as a weakness of the neurophenomenological approach, or implying a category that does not match up to the habitual manner of carrying out scientific work (Petitmengin-Peugeot, 1999). For a better understanding of how intuition is an important part of human decision-making, where analytical and non-analytical reasoning processes continually interact, being its major role to provide a conceptual foundation that suggests the directions which new research should take, we recommend the following articles (Castelhano et al., 2019; Davies, 2003; Dingledine, 2018; Erren, 2010; Greenhalgh, 2002; Hodgkinson, Langan-Fox & Sadler-Smith, 2008; Undorf & Zander, 2017; Van den Brink, Holbrechts, Brand, Stolper & Van Royen, 2019; Wilder, 1967).

3.3. Graphic model of the structure of normal temporality

Our graphic model of normal temporality is based principally on B. Dainton's "overlap extensional model" (Dainton, 2000; Foster, 1979) and on F. Varela's view of dynamical temporal flows (Varela, 1999). Both these theoretical conceptions draw on the classic phenomenological proposals of E. Hüsserl (1966) (Brough, 1991), M. Heidegger (1962) and M. Merleau-Ponty (2012).

We therefore propose a superposition of specious presents (Fig. 3). If we situate ourselves in the present moment or "now-phase", which we call SP(0) (specious present zero), we can observe how this is superposed both on the previous or "just-past" specious present, which we call SP(−1) (specious present minus one), and the immediate future or "almost now" specious present, which we call (SP+1) (specious present plus one). The influence of SP(−1) and SP(+1) on SP (0) is apparent through what we call "dynamic circles of co-determination of retention and protention", indicated in Fig. 3 as two circumferences each containing two arrows pointing in the same direction. The central detail of the figure is that these circumferences intersect at two points, forming a common area in SP0. The line which connects the two points of intersection is known in geometry

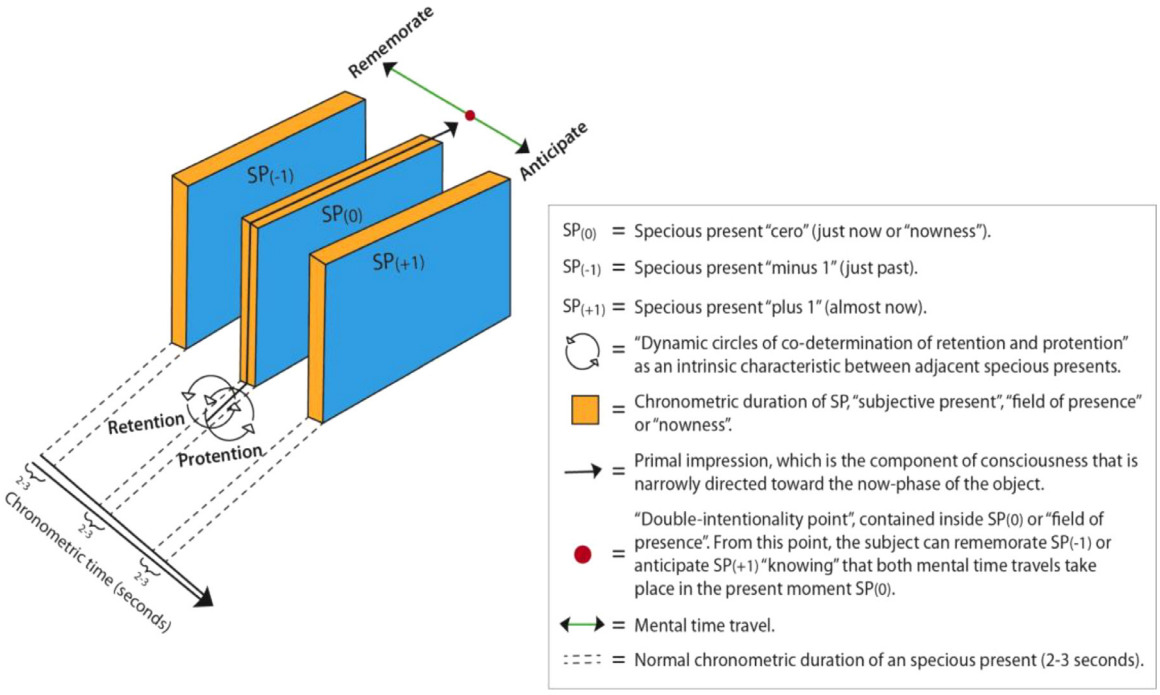

Fig. 3. Graphic model of the structure of normal temporality. We propose a superposition of specious presents. If we situate ourselves in the present moment or "now-phase", which we call SP(0) (specious present zero), we can observe how this is superposed both on the previous or "just-past" specious present, which we call SP(−1) (specious present minus one), and the immediate future or "almost now" specious present, which we call (SP+1) (specious present plus one). The influence of SP(−1) and SP(+1) on SP(0) is apparent through what we call "dynamic circles of co-determination of retention and protention", indicated as two circumferences each containing two arrows pointing in the same direction. The central detail of the figure is that these circumferences intersect at two points, forming a common area in SP0. The line which connects the two points of intersection is known in geometry as the "radical line", and coincides in our model with the "primal impression" of the now-phase. The diagram also represents what we call the "double intentionality point", which is precisely the ability of the subject to remember SP(−1) or anticipate SP(+1), without losing the perspective that both these intentional acts occur "FROM" SP(0).

as the "radical line", and coincides in our model with the "primal impression" of the now-phase. In the area of intersection common to both circles, a dynamic web of intentionalities is formed, and a field of consciousness able to contain not only the present moment but also the notion of past and the prefiguration of an imminent future.

The diagram also represents what we call the "double intentionality point", which is precisely the ability of the subject to remember SP(−1) or anticipate SP(+1) without losing the perspective that both these intentional acts occur "FROM" SP(0). As mentioned above, this ability has been called mental time travel and it appears to be a constituent element of normal temporality which is strongly preserved in *Homo sapiens* (Suddendorf & Busby Grant, 2003; Suddendorf & Corballis, 1997;2007).

Finally, our model establishes a relation between subjective time and chronometric time, since each SP presents a duration of approximately two to three seconds in *Homo sapiens*.

The present moment or SP(0) is described operationally as:

$$SP(0) = PI + RSP(-1) + PSP(+1)$$

where:

SP(0)= Now phase.

PI= Primal Impression.

RSP(−1)= Retention of SP(−1).

PSP(+1)= Protention of SP(+1).

In Fig. 4 we develop a model of temporal flows for a specious present. The top diagram (Letter a) shows how the area of superposition of the flows of retentions and protentions also contains the primal impression. We call this region the "area of synchronicity"; it is the theoretical point in which these three basic constituent elements of "now" interact with and co-determine one another. We can therefore deduce that the emergence of a "double-intentionality point", as well as the capacity to undertake mental time travel, depend on the proper constitution of the "area of synchronicity". The lower diagram (Fig. 4, letter b) shows the behaviour of the dynamic temporal flows of a specious present in a three-dimensional space to which the temporal dimension has been added. Thus in SP(0) dynamic flows of retentions and protentions are observed that co-determine one another, and are also influenced by the temporal flows that emerge from the primal impression. In contrast to the model proposed by F. Varela (1999), our model proposes what we call "super-symmetry" in temporality, with open horizons of anticipation and of remembrance which allows symmetrical mental time travel to past and future times. This means that if we fold this space-time sheet, taking as our vertical axis the line representing the primal impression which lies in

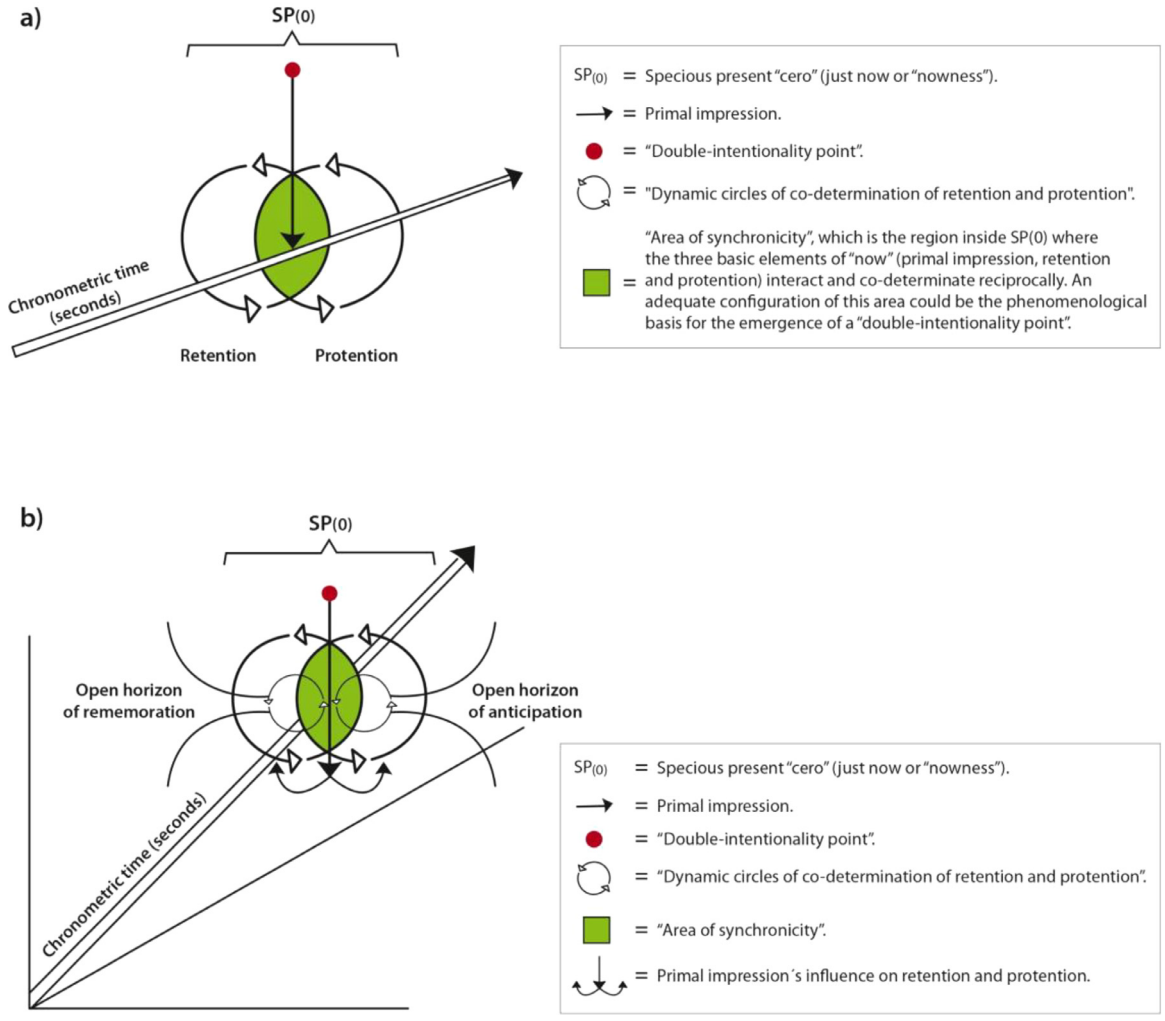

Fig. 4. Dynamic model of temporal flows for a specious present.The top diagram (letter a) shows how the area of superposition of the flows of retentions and protentions also contains the primal impression. We call this region the "area of synchronicity"; it is the theoretical point in which these three basic constituent elements of 'now' interact with and co-determine one another. We can therefore deduce that the emergence of a "double-intentionality point", as well as the ability to undertake mental time travel, depend on the proper constitution of the "area of synchronicity". The lower diagram (letter b) shows the behaviour of the dynamic temporal flows of a specious present in a three-dimensional space to which the temporal dimension has been added. Thus in SP(0) dynamic flows of retentions and protentions are observed that co-determine one another, and are also influenced by the temporal flows that emerge from the primal impression.

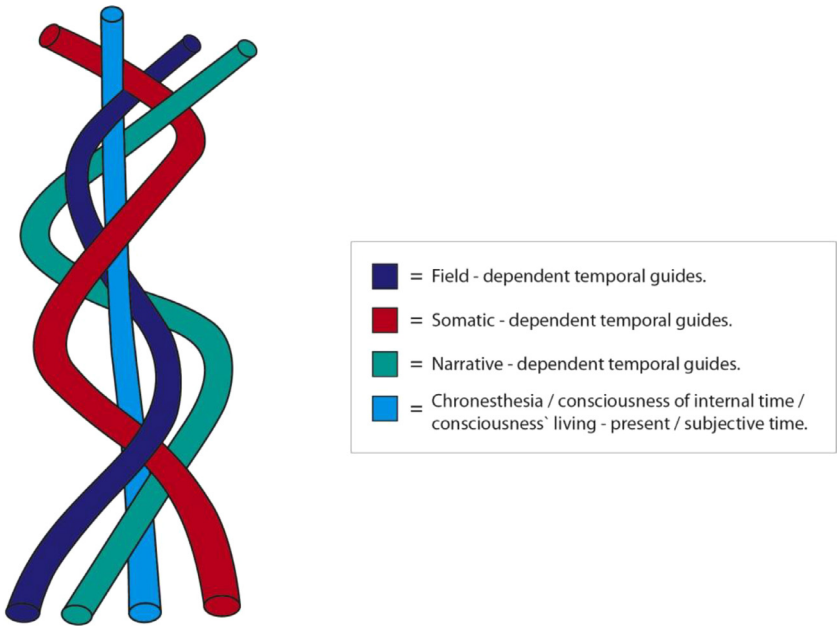

Fig. 5. Model of temporal guides (enactive chronesthesia).Our model subscribes to the idea that subjective time or chronesthesia is enactively determined by at least three variables; these act as "temporal guides", permitting continuous re-synchronisation between the various constituent elements of SP(0), and of these with chronometric or physical time. The temporal guides that we propose as necessary for the constitution of chronesthesia are: 1) field-dependant temporal guides, 2) somatic-dependant temporal guides and 3) narrative-dependant temporal guides. The enactive coincidence of these three variables moulds the emergence of subjective time or chronesthesia.

the centre of the "area of synchronicity", there would be theoretically infinite future times that would coincide with infinite past times. This is what we mean by the "super-symmetrical" nature of temporality. The central aspect of mental time travel as a normal phenomenon is that travel necessitates a traveller, a consciousness capable of preserving the perspective that his travel through the horizons of anticipation or remembrance occur FROM a "now" or SP(0). It is precisely his temporal consciousness, given its intimate structure, that allows the traveller in our model to remember or anticipate infinite temporal points FROM a present time or specious present SP(0). When we propose the possibility of mental time travel to an infinite number of past and future temporal points, we do it from the evident assumption that as our existence is finite, we cannot undertake mental time travel to moments previous to our birth or subsequent to our death. However, there is nothing contradictory about this affirmation, because we can literally remember multiple past times, each with infinite versions, just as we can envision infinite future times in infinite possibilities. We can thus state that our experience as time travellers can (in our experience) exceed the notion of existential finiteness.

3.4. Model of temporal guides: Enactive chronesthesia

Philosophers and cognitive neuro-scientists have recently argued that perception is "enactive" (Di Paolo, 2009; Gallagher & Zahavi, 2014; Varela, Thompson & Rosch, 1991). In simple words, perception is "action-orientated": when something is perceived, it is perceived as "actionable", as something that we can achieve or not, and possibly use or not. Our way of perceiving the world is moulded by this way of perceiving objects as potentially usable.

Our model subscribes to the idea that subjective time or chronesthesia is enactively determined by at least three variables; these act as "temporal guides", permitting continuous re-synchronisation between the various constituent elements of SP(0), and of these with chronometric or physical time. The temporal guides that we propose as necessary for the constitution of chronesthesia are: 1) field-dependant temporal guides, 2) somatic-dependant temporal guides and 3) narrative-dependant temporal guides. The enactive coincidence of these three variables moulds the emergence of subjective time or chronesthesia (Fig. 5). Below we describe each of these temporal guides:

1) Field-dependant temporal guides refer to all the "afferencies" or sensory inputs, derived from the environment, which impart rhythmicity. Here we will define as an afferency or rhythmic input any stimulus which is not continuous in duration and/or intensity but which presents a cadence or repetitive pattern. Thus any stimulus which is discontinuous or which changes in intensity will present a minimal rhythmic quality, namely that it is distinguishable from the background or intrudes as an object of consciousness. Just as the minimum spatial structure that can be distinguished ontogenically from its environment is a sphere (for example the lipid membrane of a cell), the basic condition for an afferency to be a temporal guide is that it presents discontinuity and/or variation in intensity. Some everyday examples of field-dependant temporal guides are: changes in luminosity, the observation of our own or other people's motor sequences, sound cadences (e.g. the rhythmicity of speech, melodies, the tides, the sound of steps, the ticking of a watch or the distant whistling of the wind). Other notable examples are smells that we perceive suddenly, and tactile sensations.
2) Somatic-dependant temporal guides refer to all those biological functions that occur at circadian intervals or which are discontinuous and/or variable in intensity. Some examples are melatonin or cortisol peaks, cardiac and respiratory rhythms, and the frequency of urination. Here also we find our unique way of moving in space spontaneously and without effort, an old concept that von Monakow called the "kinetic melody" (Luria, 1973). Thus our particular way of behaving kinetically in the fabric of space-time also models our subjective time or chronesthesia.
3) Narrative-dependant temporal guides refer to our ability as a species to auto-narrate our existence. Thus constructivist theory defines us as inveterate seekers after meaning, individually or collectively, through narratives with high internal coherence and social acceptance (Luria, 1973; Neimeyer, 2001). The narration of how our life unfolds, whether or not we communicate it, will be

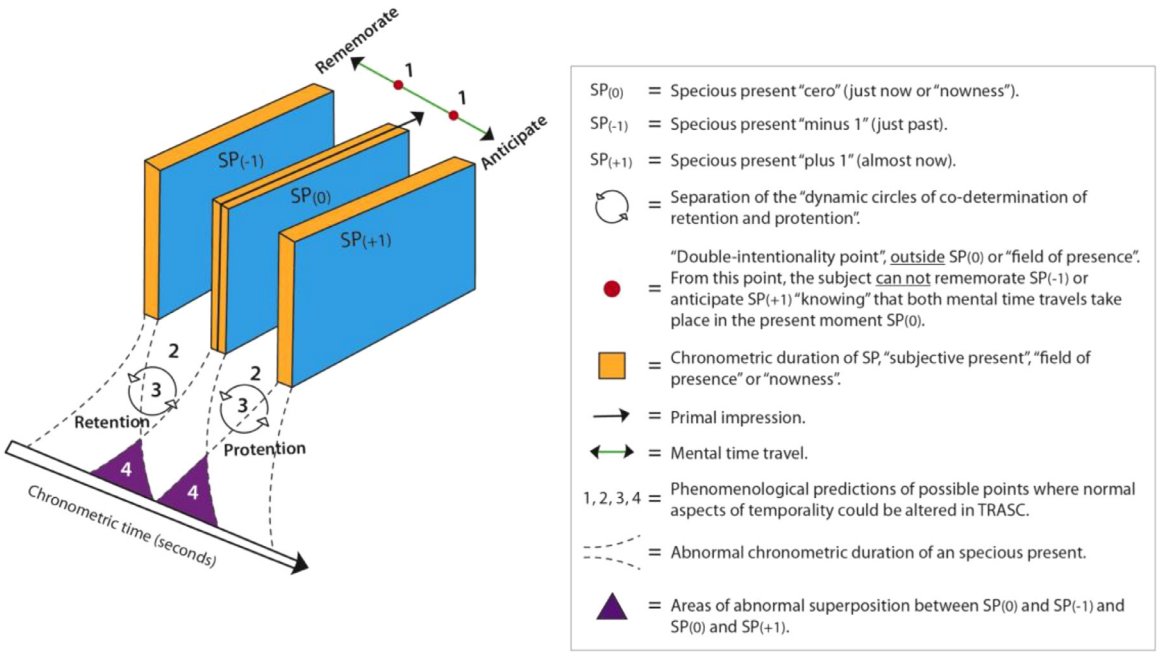

Fig. 6. Model of altered temporality in TRASC.Patients with alteration of the temporal dimension derived from a psychic trauma may present difficulties in mental time travel. This would be a natural consequence of the fact that the "double-intentionality point" is outside SP(0). Thus, would be non-coincidence between that point and the primal impression. What is lost, from a phenomenological analysis, is the capacity of the subject to remember or anticipate events FROM a present moment (number 1 in the figure). The dissolution of the "area of synchronicity", together with the abnormal chronometric duration of a specious present, should result in different alterations in the perception of physical time by the patients (numbers 2 and 3 in the figure). Areas of abnormal superposition between adjacent specious presents (purple areas with number 4), may lead to experiences of temporal overlapping which are phenomenologically distinct from a flashback. In these experiences, the patient may behave and experience the world with the same affective and cognitive stamp as in a traumatic past time, but without re-experiencing the specific traumatic event. In experiences of this kind it is the phenomenal consciousness that is altered, understood as the ability to experience the qualitative nature of the experience.

an important part of how chronesthesia is constituted. A simple example of how our personal narrative affects our subjective time can be seen every time we communicate in a language that is not our own. If we observe the phenomenon with sufficient subtlety, we will realise that we change not only our mode of expression, but also the temporal experience of the development of our ideas and our contact with the environment. The syntax and expressiveness of each language offer us constituent elements that are unique to our experience at the time.

3.5. Neurophenomenological model proposed for alterations of temporality in TRASC

3.5.1. Regions in the structure of normal temporality that may be altered in PTSD with TRASC

Thus it can be proposed intuitively that trauma alters the intimate mechanism of the constitution of now, given by the interaction of co-determination between the dynamic flows of retention and protention, from the meeting of which nowness emerges. On the other hand, it is probable that one region of the model of normal temporality that can be altered by trauma is the relation between SP(0) and chronometric time, and between SP(0) and the functions that constitute mental time travel. In this respect, we must have recourse to the idea that anyone who travels in time is able to perform self-observation from a reference point constituted by now. We base this assertion on Hüsserl's concept of "double intentionality" and "transverse intentionality", which – as mentioned in Section 1.2.2 – is the consciousness of our ability simultaneously to experience the flow of time and to position ourselves from now towards the object of intentionality, whether it exists in the chronometric past, present or future. Turning to the interaction between SP(0) and chronometric time, we found data indicating that patients with PTSD experience alterations both in the perception of chronometric time and in the prediction of the duration of intervals of physical time (Brough, 1991; Carvalho, Chaim, Sanchez & de Araujo, 2016; Hüsserl, 1966; Lloyd, 2012).

In this way, accepting the fact that a new conceptualisation of altered temporality in TRASC will present an intuitive aspect, we have derived a theoretical model of altered temporality in TRASC (Fig. 6). Thus the model shows four aspects of the internal structure of temporality that might theoretically be altered by trauma:

1) The "double-intentionality point" is outside SP(0) or the "field of presence". This would result in the subject (or time traveller) losing the ability to distinguish the fact that his remembrance of SP (−1) or anticipation of SP(+1) occur FROM the present moment or SP(0).
2) A separation occurs of the "dynamic circles of co-determination of retention and protention". Thus both flows would lose the region of superposition in SP(0), in the centre of which the primal impression is normally found. The "area of synchronicity" would suffer dissolution, and the fine interaction between the basic constituents of the now (primal impression, retention and protention) would be lost.
3) Trauma may damage the intrinsic mechanisms of retention and protention. The real nature of these mechanisms is hidden to our understanding, and it is here that the final, impenetrable nature of consciousness brings us to a terminal point in which no further data can be deduced from a purely theoretical neurophenomenological analysis.
4) Finally, it is conceivable that the chronometric duration of specious presents is also altered by trauma. The result of this is shown in purple in Fig. 6, with an abnormal superposition of temporality between SP(0) and SP(−1), and between SP(0) and SP(+1).

Based on this model of altered temporality in trauma, we offer in the Discussion seven logical consequences, which can be derived

quite naturally. If empirically or clinically corroborated, these likely consequences would support our model.

4. Discussion

4.1. Logical consequences from the model of altered temporality in TRASC

The following logical consequences can be derived from the model of altered temporality in TRASC proposed in Fig. 6:

1) Patients with alteration of the temporal dimension derived from a psychic trauma may present difficulties in mental time travel. This would be a natural consequence of the fact that the "double-intentionality point" is outside SP(0). What is lost, from a phenomenological analysis, is the ability of the subject to remember or anticipate events FROM a present moment; his perspective is that the event that is remembered or anticipated is happening in the "now". The same phenomenon would occur in a flashback, one of the most characteristic clinical indications of PTSD with TRASC.
2) A second consequence of the fact that the "double-intentionality point" is outside SP(0) would be non-coincidence between that point and the primal impression. The clinical consequence derived from this would be that what is experienced by the consciousness in the immediate present will emerge with a quality that differs from the habitual; the sensation of unreality will capture experience in the form of depersonalisation, derealisation or "out-of-body experiences". In clinical experiences of this type, it is evident how alterations in the intimate structure of temporality become chronesthesic alterations.
3) The dissolution of the "area of synchronicity", together with the abnormal chronometric duration of a specious present, should result in different alterations in the perception of physical time by the patient. Difficulties may be encountered in predicting the duration of a determined stimulus, or in incorporating sequential elements that occur within the indifference interval of two to three seconds as part of a single percept. These alterations in the structure of temporality are observed clinically as failings in attention, in short term memory or in the comprehension of percepts, given the difficulty of perceiving them as a significant whole.
4) Areas of abnormal superposition between adjacent specious presents (purple areas in Fig. 6) may lead to experiences of temporal overlapping which are phenomenologically distinct from a flashback. In these experiences, the patient may behave and experience the world with the same affective and cognitive stamp as in a traumatic past time, but without re-experiencing the specific traumatic event. In experiences of this kind it is the phenomenal consciousness that is altered, understood as the ability to experience the qualitative nature of the experience. This concept has been called "Qualia" by some authors (Coward & Sun, 2004). Examples of phenomena of this kind are found when a patient says that he has felt experientially the same as in past times, but without referring explicitly to a particular traumatic instance that took place in his life at that time. It is very difficult to determine whether these are phenomena of depersonalisation-derealisation or "numbing", since experiences of this kind are poorly described in the literature. Experientially, the phenomenon bears some similarity to "*déjà vu*"; and, like *déjà vu*, is experienced with surprise and sometimes with some degree of perplexity.
5) The model's description of the existence of temporal "super-symmetry" leads to the logical consequence that just as flashback exists, there should also be a mirror-image phenomenon of similar characteristics but projected into a future time. This phenomenon, less frequently addressed in the literature, is what psychic trauma experts know as "flashforward"; it has been described not only in trauma, but also in affective disorders in the form of mental images of ominous future acts, including suicide (Hales, Deeprose, Goodwin & Holmes, 2011; Loganovsky & Zdanevich, 2013).
6) Some of the contemporary therapeutic approaches to PTSD may exercise part of their effect by promoting temporal re-synchronisation in the patient. Several of these methods explicitly promote the presentification of the patient, recover the experience of corporaleity from now, or present different rhythmic stimuli, which may be visual, tactile or auditory, as part of the method (Boyd, Lanius & McKinnon, 2018;Odgen, Minton & Pain, 2006; Porges, 2011; Shapiro, 1989;2018). Based on our proposed model of altered temporality, these therapies could be conceptualised from a novel perspective.
7) The last logical consequence derives from the incorporation of the concepts presented in Fig. 5, in what we call the temporal guides model in the context of enactive chronesthesia. Thus an altered temporality would affect the "narrative-dependant temporal guides"; in a patient this would be expressed as difficulties in narrating his traumatic history coherently or with a sense of ownership and agency. Thus we find, for example, incomprehensible interpretations of the trauma itself, and of the unfolding of the patient's life experience. Furthermore, altered forms of narration are observed, sometimes "disconnected" from the emotional as if the traumatic experience had been lived by another person. Likewise the "somatic-dependant temporal guides" will be affected, with expressions ranging from alteration of sleeping-waking rhythms, heart-rate, respiratory rate, melatonin or cortisol peaks to loss of grace, naturalness and fluidity in the kinetic melody. Finally, alterations of the "field-dependant temporal guides" have already been addressed when we mentioned that the external stimuli habitually considered as a single percept may now lose this character. We must stress that the theoretical consequences of this seventh point do not claim to indicate a directionality of the phenomena described. We are not saying that alterations in the structure of temporality in trauma affect the other three strands of the model (narrative, somatic and field-dependant temporal guides). On the contrary, we only note that the degree of interweaving and co-determination between the four strands makes it highly likely that if one of them is altered, the others will also emerge altered, and that these anomalies will be fed back in a "loop" of reciprocal co-determination.

4.2. Common neurobiological correlates in PTSD with TRASC, altered chronesthesia and the symptomatology of PTSD: An initial starting point to support our model

To date no research has been able to establish a precise neurobiological correlate for the theoretical proposal that we develop in this article. However, we can deduce how certain alterations previously studied in different areas of the brain and neural networks could be candidates as possible correlates of this model.

We have said that the "double-intentionality point" would be altered when it was situated outside SP(0). Clinically, we can distinguish two post-traumatic phenomena which might account for this alteration: 1) the experience of flashback, i.e. the sensation of re-living the traumatic experience; and 2) flashfoward, the experience of projecting the self vividly into the future (Hales et al., 2011; Loganovsky & Zdanevich, 2013). In patients with PTSD who experience flashbacks, greater activity has been observed in areas like the bilateral anterior insula, somatosensory cortex, cerebellum and cerebral brainsteam, as well as a lower level of activity in areas like the bilateral dorsolateral prefrontal cortex, right fusiform cortex, right medial temporal cortex, and precuneus (Brewin, 2015; Hall, Gjedde & Kupers, 2008; Hopper et al., 2007; Osuch et al., 2001; Whalley et al., 2013). Moreover, a group of cells known as "time cells" has been

described in the hippocampus, which are thought to be able to encode moments in temporally structured experiences (Eichenbaum, 2013; MacDonald, Lepage, Eden & Eichenbaum, 2011). Lesions in these cerebral structures are related with severe deficits of episodic memory and alteration of the capacity for mental time travel (Andelman et al., 2010; Hassabis et al., 2007; S. B. Klein et al., 2002; Tulving, 1985; Klein, Loftus and Kihlstrom, 2002b) Other investigations in subjects with PTSD have reported that they present a decrease of functional connectivity in repose between the hubs of the Default Mode Network (DMN), concentrated predominantly in the medial-temporal sub-system. This is probably associated with re-experiencing, related with alteration of autobiographical memory (Bluhm et al., 2009; Brewin, 2015; DiGangi et al., 2016; Miller et al., 2017; Sripada et al., 2012). The DMN starts to mature during childhood and the process does not end until early adulthood; therefore when maltreatment and/or trauma are repeated frequently in these maturing stages, they alter the development of the DMN, presenting different patterns of connectivity during repose; its functioning is altered especially in conditions related with threats or trauma (Lanius, Terpou & McKinnon, 2020). As mentioned above, the 4-D model predicts that patients who present PTSD with TRASC are more likely to present early and repetitive traumas. Flashfoward, in contrast, is a phenomenon scarcely described in the literature, and indeed it is not clear whether it is a strictly post-traumatic phenomenon (Hales et al., 2011; Loganovsky & Zdanevich, 2013). More research is needed to try to dilucidate the clinical characteristics and neurobiological bases of this phenomenon.

Another clinical consequence of the fact that the "double-intentionality point" is outside the SP(0) could be depersonalisation, derealisation and out-of-body experiences. Although the pathogeny of depersonalisation/derealisation has not been established, it is generally assumed that this syndrome is manifested in individuals who have inherent diatheses combined with psychological and/or chemical stress factors. The role of trauma in depersonalisation/derealisation has been well described in potentially mortal traumatic situations (Noyes & Kletti, 1977; Noyes, Hoenk, Kuperman & Slymen, 1977) and it is speculated that this response is programmed in the brain, so that a sensation of distance and disconnection with the traumatic event can facilitate survival and negotiation without the feeling of an overwhelming and disorganising emotion (Noyes & Kletti, 1977; Noyes et al., 1977). Nevertheless, the acute symptoms of depersonalisation and derealisation that occur in such circumstances generally disappear within minutes, hours or days, and this does not explain how the symptoms become chronic. The latter tends to occur amongst people with a background of verbal or emotional abuse or neglect during childhood, in other words, those who are most likely to present PTSD with TRASC (Simeon, Giesbrecht, Knutelska, Smith & Smith, 2009, 2001). Other similar situations include growing up in fear of a parent with severe mental illness, a traumatic struggle with sexual orientation, or exeriencing the unexpected death or suicide of a family member or a close friend. It has also been reported that chronic symptoms of depersonalisation and derealisation occur in subjects with affective or anxiety disorders (Simeon, Knutelska, Nelson & Guralnik, 2003). Various neuro-transmitter systems, cerebral regions and functional circuits have been associated, fairly consistently, with symptoms of depersonalisation and derealisation. First, the neuro-chemical system dependant on the NMDA receptor: these receptors are widely distributed in the cerebral cortex, the hippocampus and the amygdala, and mediate associative processes; thus the NMDA antagonist ketamine induces a profound dissociative state in healthy subjects that differs, both phenomenologically and in terms of the cerebral paths involved, from the psychotomimetic effects of this drug (Anand et al., 2000; Deakin et al., 2008). Second, the endogenous cannabinoid system: cannabinoids block the NMDA receptors in different sites from other, non-competitive NMDA antagonists (Feigenbaum et al., 1989); therefore their dissociative effect may be partly mediated by the NMDA antagonism, as well as by the endogenous cannabinoid system. Third, kappa opioid agonists: in an experimental study in healthy volunteers, the kappa opioid agonist enadoline induced a syndrome similar to depersonalisation, with alterations of perception and a sensation of detachment in the absence of prominent effects on mood or anxiety, or psychotomimetic effects (Walsh, Strain, Abreu & Bigelow, 2001). Fourth, serotonin agonists: hallucinogens that act as agonists on the serotonin 5HT2A receptors, and especially 5HT2C, have been shown to induce depersonalisation in a cohort of patients who presented social phobia, borderline personality disorder and obsessive-compulsive disorder (Simeon et al., 1995), as well as induction of flashbacks and dissociative symptoms in a sub-group of patients with PTSD (Southwick et al., 1997).

Findings in neuroimages in depersonalisation disorders have shown altered activity in the area of the inferior parietal lobe, in particular in the right hemisphere; this finding has been related with out-of-body experiences (Blanke, Ortigue, Landis & Seeck, 2002). Another altered area is the insula, where hypo-activation is triggered by greater prefrontal inhibition; this alteration has been related with hypo-emotionality and overthinking (Lemche et al., 2007; Phillips et al., 2001). On the other hand, findings in neuroimages during the presentation of scripts associated with the trauma have found hyperactivity in the prefrontal cortex (PFC) and suppression of activity in the amygdala and the insula, which matches the theory of the suppression of affect (Lanius et al., 2010). Thus these regions of the brain, neuronal circuits and neurotransmission systems would be the preferred candidates for studying the neurophysiological substrate that may be related with alterations of the structure of temporality in what we have described in our model as a double intentionality point outside SP(0).

Our model also proposes that dissolution of the "area of synchronicity", together with the abnormal chronometric duration of a specious present, should result in different alterations in the perception of physical time by patients. Initially it was shown that in high arousal/threat situations, a slowing of the perceived passing of time occurs, known as "overestimation of time" (Angrilli, Cherubini, Pavese & Mantredini, 1997; Bar-Haim, Kerem, Lamy & Zakay, 2010; Campbell & Bryant, 2007; Yoo & Lee, 2015). Based on this evidence, a first study was designed in patients with PTSD versus healthy subjects, in which the ability to predict the duration of a visual stimulus was measured. The principal result of this study was to show an overall time overestimation in PTSD compared to the control participants. Secondly, these results were correlated with greater alterations in the working memory and in attention impairments in the PTSD group (Vicario & Felmingham, 2018). This report proposed that: "It is possible that individuals with PTSD may have an underlying disturbance in temporal processing independently of emotional or stressful contexts". The findings described correlate with the evidence of cerebral alterations (structural and functional) in patients with PTSD, in regions associated with the experience of chronometric time: the dorsolateral prefrontal cortex, the superior parietal regions, the insula and the basal ganglia (Eckart et al., 2011; Geuze et al., 2008; Hughes & Shin, 2011). From the neuro-chemical point of view, the role of dopamine with respect to the internal clock functions, as well as the dopaminergic dysfunction described in PTSD, would support more strongly the hypothesis that relates alterations in the perception of time with this pathology (Koch et al., 2008; Lewis & Miall, 2006; Meck, 1996).

Considering the clinical expression of patients who present PTSD with TRASC, specifically what in our model we call areas of abnormal superposition between adjacent specious presents (purple areas in Fig. 6), we observe individuals who say that they behave and experience the world with the same affective and cognitive stamp as in a traumatic past time, but without re-experiencing the event. One example is the case of a patient, aged 36 years, treated by our team

when he was going through a particularly traumatic divorce. Some years after the divorce, the patient passed through the neighbourhood where he had lived with his ex-wife. A few minutes after leaving the local Metro station, he started to experience an emotional and cognitive stamp similar to that experienced during the period of his divorce. The patient described the experience as follows: "*I felt as I had in those years, but it was not an unpleasant experience, it was just different*". He did not report flashbacks, intrusive memories, conducts of avoidance or egodystonic feelings. The patient went into a payment centre to make a payment for his mobile telephone; when he was asked for the number he repeated the same wrong number three times, until he had to look in the mobile where he had noted the correct number. When he reached home that evening, no longer in the affective-cognitive state that he had experienced in the afternoon, he wrote down the number that he had repeated three times in the payment centre. Then he looked in his records and found to his surprise that it was the number of the house where he had lived with his ex-wife, which he declared that he could not remember in a state of "*normal consciousness*". Diagnostic classification systems existing today do not describe this phenomenon, so it would tend to be accommodated in psychopathological descriptions such as depersonalisation/derealisation or numbing. Because of this difficulty in describing and classifying such experiences, there are no neurobiological findings for a phenomenon such as this. More complete psychopathological exploration to find out whether experiences of this type present sufficient stability to constitute a clinical descriptive category would appear to be the natural first step in exploring this phenomenon. In our opinion, experiences of this type represent an alteration in the "Qualia" or phenomenal consciousness, and may be due to the superposition of specious presents (sometimes very distant from one another), since they are considered from the perspective of chronometric time.

Another logical consequence of our model supports the idea that chronesthesia is enactively determined by three variables or "temporal guides": 1) field-dependant temporal guides; 2) somatic-dependant temporal guides; and 3) narrative-dependant temporal guides. In this context we may mention that mammals are provided with a circadian rhythm system, which can be seen as nothing less than a network of circadian clocks. This network allows optimal organisation of time and anticipation of the biological functions related with periodic variations in the environment; thus circadian rhythms allow individuals to make physiological and behavioural adaptations to meet environmental changes (e.g. fluctuations in the cycle of light and darkness) (Tordjman, 2013). Likewise "somatic" rhythms, such as the physiological rhythms of maternity, play an important role in foetal development. Stable, repetitive physiological rhythms, associated with transmodal perception, allow the foetus to incorporate sensory information and develop a coherent representation of its internal and external surroundings. Thus soma and environment participate in the establishment of a secure emotional base. These rhythmic experiences are established in early childhood (for example, experiences of rhythmic feeding) and begin even earlier, in the uterus (e.g. the experiences of sound and rhythm perceived in the uterus by the foetus). To generate a feeling of self-security, the individual's internal (somatic) physiological rhythms must be in harmony with the rhythms of the environment. These internal and external rhythms allow individuals to develop their experiences of themselves and their surroundings, and thus construct their representation of the body and the self (Tordjman, 2013). Recognising that our chronesthesia emerges from co-determination by somatic, environmental and self-narrative variables, and recognising the role of rhythmicity as an important component of our chronesthesia, could open interesting paths towards new therapeutic approaches to PTSD with TRASC. Experimental examples on how manipulation of external (physical) clocks results in alterations in the subjective speed of time can be found in the excellent review by Thönes, Arnau and Wascher (2018)). For a detailed explanation on the co-determination of self, episodic-autobiographical memory, and autonoetic consciousness, and how these variables are connected by their embeddedness in time, see the report by Markowitsch and Staniloiu (2011).

For a better understanding of the possible neurobiological correlations between the symptoms of altered temporality in PTSD with TRASC and the neurophysiological bases of chronesthesia and mental time travel, see Table 3. (Addis, Wong & Schacter, 2007; Andelman et al., 2010; Angrilli et al., 1997; Bar-Haim et al., 2010; Bertossi, Tesini, Cappelli & Ciaramelli, 2016; Bluhm et al., 2009; Brewin, 2015; Buckner & Carroll, 2007; Campbell & Bryant, 2007; Carvalho et al., 2016; Chiong, 2011; Craig, 2009; DiGangi et al., 2016; Eckart et al., 2011; Eichenbaum, 2013; Geuze et al., 2008; Hales et al., 2011; Hall et al., 2008; Hassabis et al., 2007; Hopper et al., 2007; Hughes & Shin, 2011; Karapanagiotidis, Bernhardt, Jefferies & Smallwood, 2017; S. B. Klein et al., 2002; Koch et al., 2008; Kurth, Zilles, Fox, Laird & Eickhoff, 2010; Lanius et al., 2020; Levine et al., 1998; Lewis & Miall, 2006; Lloyd, 2012; Loganovsky & Zdanevich, 2013; MacDonald et al., 2011; Meck, 1996; Miller et al., 2017; Nieuwenhuys, 2012; L. Nyberg et al., 2010; Okuda et al., 2003; Østby et al., 2012; Osuch et al., 2001; Sripada et al., 2012; Szpunar, Watson & McDermott, 2007; Tulving, 1985; Vicario & Felmingham, 2018; Whalley et al., 2013; Yoo & Lee, 2015).

These possible correlations do not imply either causality or directionality, but they may constitute a starting point for future research based on our model of altered temporality in TRASC. So far as we know, there are no suitably designed studies which investigate the neural correlates of the other alterations of temporality described previously in our model.

4.3 Possible implications of our model for a novel comprehension of the therapeutic approaches to PTSD

From a therapeutic angle, it is fundamental to strengthen the self in trauma survivors, in order to facilitate the emergence of a mental time-traveller who is able to remember the past instead of re-living it. According to our model, this could be equivalent to the idea of "*temporal resynchronisation interventions*". To this end we propose that: secure relations should be built up, including the therapeutic relationship; full attention on the present should be improved with mindfulness exercises; the therapist should work on emotional regulation skills and tolerance of discomfort; and the ability to tolerate positive affects should be developed. In view of the above, strengthening of the feeling of the self by the use of therapies focused on the present, in combination with exposure therapies, may be crucial for overcoming flashbacks successfully (Cloitre et al., 2010; Ford & Russo, 2006; Frost, Laska & Wampold, 2014). More specifically, overcoming the fragmentary or atemporal nature of traumatic memories, increasing emotional consciousness and helping PTSD patients to recover their corporeality are important components of therapies that focus on both the past and the present. Examples of these therapies are: cognitive processing therapy (CPT)(Resick & Schnicke, 1992); prolonged exposure therapy Foa, Hembree & Rothbaum, 2007); eye movement desensitization and reprocessing (EMDR)(Shapiro, 2018) and full attention therapy (Boyd et al., 2018; Frewen & Lanius, 2015; Lanius, Bluhm & Frewen, 2011). The therapeutic responses to these clinical approaches eloquently reflect the functions of recovered DMN. Furthermore, various therapies used to treat PTSD which focus on the present and the past, including full attention training (King et al., 2016), neuro-feedback (Kluetsch et al., 2014), EMDR, cognitive behavioural therapy (CBT) and prolonged exposure, have been shown to restore the functioning of the whole DMN while the patient desists from intentioned cognitive activity. In accordance with the inhibitory view of extinction learning and the theory of the dual representation of PTSD, the success of these therapies – EMDR for example – suggests that contextualisation of the traumatic memory, making the patient focus his attention deliberately on himself in a secure environment or introducing elements of security into the traumatic image, is a critical mechanism. This may include

Table 3
Possible neurobiological correlations between symptoms of altered temporality in PTSD with TRASC and neurophysiological bases of chronesthesia and MTT.

Symptoms of altered temporality in PTSD with TRASC and its corresponding description in our model	Neurobiological findings in PTSD with TRASC	Neurophysiological bases of chronesthesia and MTT	Possible correlations between symptoms of altered temporality in PTSD with TRASC, and chronesthesia/MTT
- Flashbacks *(Double-intentionality point outside SP0)	- Anterior insula (bilateral) - Somatosensory cortex - Cerebellar regions - Brainstem - Dorsolateral prefrontal cortex (bilateral) - Fusiform cortex (right) - Medial temporal cortex (right) - Midbrain - Parahippocampal gyrus - Precuneus - DMN	- Anterior insula - Hippocampal bilateral lesions - Frontopolar/medial temporal networks - Superior frontoparietal cortex - Ventral frontal cortex (right) - DMN - vmPFC - Lateral parietal cortex - Cerebellum - Thalamus	- Anterior insula - DMN - Frontopolar and medial temporal networks - Cerebellum
-Altered perception of chronometric time. *(Dissolution of the area of synchronicity and abnormal chronometric duration of SP).	- Dorsolateral prefrontal cortex - Superior parietal regions - Insula - Basal ganglia - Alterations in dopaminergic systems	- Same structures stated in the previous row of this column. - Role of dopaminergic pathways in the basal ganglia - Role of acetylcholine pathways in the frontal cortex	- Insula - Prefrontal cortex - Superior parietal cortex - Basal ganglia (dopaminergic pathways)

Based on contemporary evidence, the most possible regions of interest correlating the neurobiology of flashbacks with chronesthesia/MTT are: the insula, DMN, the frontopolar and medial temporal networks and the cerebellum. In the case of altered perception of chronometric time, the regions of interest are: the insula, the prefrontal cortex, superior parietal cortex and the basal ganglia with its dopaminergic pathways.
(Functional and structural findings were considered, but specific alterations on each region were intentionally excluded as data remain heterogeneous. For a complete review of these findings, see references in Section 4.2).
* Alteration of the normal structure of temporality proposed by our model.
PTSD: Post Traumatic Stress Disorder.
SP0: Specious present zero (refer to Fig. 6).
SP: Specious present.
TRASC: Trauma-Related Altered States of Consciousness.
MTT: Mental Time Travel.
DMN: Default Mode Network.
vmPFC: ventromedial prefrontal cortex.

contextualisation methods which are known to increase hippocampus activity, like imagining the scene from an alternative perspective (Kaur, Murphy & Smith, 2016). Another promising therapeutic intervention for PTSD is neuro-feedback: greater connectivity has been found between the precuneus and the posterior DMN (pDMN) in patients with PTSD compared to a control group (Nicholson et al., 2020). After the intervention with neuro-feedback, the group of patients with PTSD showed reduced connectivity between the precuneus and the pDMN compared to the baseline condition before treatment. After treatment, 61.1% of the PTSD group did not meet the criteria for this disorder (Nicholson et al., 2020).

Thus our model invites therapists to conceptualise the different therapeutic approaches to PTSD as "*temporal resynchronisation interventions*". These therapeutic models may operate in part through correction of the alterations described in the structure of temporality, especially from somatopsychic inputs or "bottom-up correlations" (Aposhyan, 2004; Caldwell, 1996; Kurtz, 1990;Odgen et al., 2006; Porges, 2011).

4.4. Answering the questions formulated

Question 1: What logical consequences can we derive from a graphic model of temporality in TRASC based on neurophenomenological analysis?

1) Patients with alteration of the temporal dimension derived from a psychic trauma may present difficulties in mental time travel.
2) What is experienced by the consciousness in the immediate present will emerge with a quality that differs from the habitual; the sensation of unreality will capture experience in the form of depersonalisation, derealisation or "out of body experiences".
3) The alterations in the structure of temporality described by our model should result in different alterations in patient's perception of chronometric time. Difficulties may be encountered in predicting the duration of a determined stimulus. The patient's difficulties in appreciating different afferecies as a single meaningful percept may cause him/her to experience failings in attention, short term memory or understanding percepts.
4) Patients with a traumatic alteration of temporality may present periods in which they perceive themselves from the point of view of the phenomenal consciousness, as they did in previous times which proved traumatic. Here there is no explicit narration of the traumatic episode, but an altered experience of the "self " and its relation with the world.
5) The model's description of the existence of a temporal "supersymmetry" leads to the logical consequence that flashbacks and flashforwards are mirror-image temporal phenomena derived from the open, symmetrical structure of temporality altered by trauma.
6) Our model proposes that some methodologies for treatment of PTDS could act as "*temporal resynchronisation interventions*", and this could be related with some aspects of their clinical efficacy.
7) The model proposes that – given the high level of reciprocal interweaving and co-determination between the four strands of the temporal guide model (presented in Fig. 5), together with chronesthesia altered by trauma – alterations may emerge in the "narrative-dependant temporal guides", the "somatic-dependant temporal guides" and the "field-dependant temporal guides".

Question 2: Can altered chronesthesia be proposed as a phenomenon related with the dissociative disorders that affect how time is experienced in TRASC?

Our answer to this question is Yes. As temporality is one of the pre-noetic constituents of consciousness, it is highly likely that psychic trauma and the way in which this alters the intimate structure of temporality determine the emergence of a temporal consciousness or chronoethesia, which is likewise altered. This altered chronesthesia, given its high degree of interweaving with what we have called temporal guides under the four strands model, will determine a multiplicity of clinical phenomena proper to dissociative states secondary to trauma. The neurophysiological correlation observed between PTSD with TRASC and chronesthesia might lead us to hypothesise a relation between them, even if it is impossible to establish directionality or causality (Table 3).

The central question: What is the nature of the alteration of temporality in Trauma-Related Altered States of Consciousness?

The nature of the alteration of temporality in Trauma-Related Altered States of Consciousness could be a disruption on the intimate structure of lived time, both in its general aspects as in its microstructure. Under these conditions a different kind of chronesthesia would emerge, implicating a different qualitative experience of self, chronometric time and the surroundings; this fundamental attribute of consiousness is also known as “phenomenal consciousness”. The exact mechanisms to explain how traumatic events alter the normal structure of temporality and chronesthesia still unknown and could only be hypothetically derived from indirect evidence. Thus at the present moment there are no specific data on this matter. To the best of our knowledge, this is the firs theoretical report that approach these questions from different epistemologies, without losing a clinical perspective.

5. Conclusions

Our neurophenomenological analysis of the structure of temporality in TRASC is based on extensive knowledge-gathering from different epistemologies. As a result, we propose a model of normal temporality from which the theoretical points possibly altered in PTSD with TRASC, as well as the clinical consequences of these alterations, can be derived naturally.

Our descriptive graphic model for a structure of temporality altered by trauma presents four basic characteristics: 1) A “double-intentionality point” displaced outside SP(0); 2) Dissolution of the “area of synchronicity”; 3) Alteration of the intrinsic mechanisms of retention and protention; and 4) Alteration of the chronometric or physical time of the specious presents. Thus our report proposes that patients who present PTSD with TRASC may experience alterations in the normal structure of temporality. These alterations in temporality would lead to altered chronesthesia, and these two aspects (altered temporal structure and altered chronesthesia) could underlie the clinical manifestations observed in this group of patients, specifically the temporal dissociation components described in the 4-D model.

From the point of view of neurophenomenological analysis, the most distinctive aspect of the model is the fact that in the altered state of consciousness secondary to a trauma, loss of the temporal perspective occurs in a person who experiences the phenomena of post-traumatic dissociation, either from past events or symptoms referring to a future time. At the centre of this alteration is the loss of the ability to distinguish that these mental activities occur FROM the present moment, their theoretical basis being a “double-intentionality point” outside the SP(0) or “field of presence”

From a practical view, this model could offer a new perspective for understanding the psychopathology of trauma, and some of the mechanisms by which therapeutic strategies operate.

One of the limitations of our model is that it does not explain how the phenomenology of emotion alters the perception of time (Droit-Volet & Gil, 2009; Droit-Volet & Meck, 2007; Noulhiane, Mella, Samson, Ragot & Pouthas, 2007; Smith, McIver, Di Nella & Crease, 2011). Future reviews of the model must address this limitation and explain how altered chronesthesia may be inter-related with emotional variables.

Other limitations of the model presented are those faced every time that the problem of temporality and consciousness is addressed in any of its forms, and especially when we enter the terrain of altered states of consciousness. When we refer to the subjective perception of time and its possibilities, both normal and those found in TRASC, we are speaking about a state of consciousness; therefore we will encounter the recognised conceptual limitations of this field, known as “the hard problem” (Coward & Sun, 2004; Kriegel, 2006; Varela, 1996). We may thus expect that a point exists beyond which we cannot progress by phenomenological analysis.

On this point, we must note that far from proposing this model as a definitive solution to the problem of temporality in TRASC, we present it rather as a systematic way of understanding theoretically how the intimate structure of temporality is altered in these patients, in order to subject the model's various logical consequences to experimental study. We thus adopt the posture of the eternal beginner, who when faced with great theoretical problems does not cling to a model, but proposes subjecting them to experimental analysis, in order to start again from scratch if necessary.

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