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Temporal frames of reference

Abstract: Based on linguistic and behavioural evidence, representations for time appear to be structured in terms of space (e.g., Casasanto and Boroditsky 2008; Lakoff and Johnson 1980, 1999). This finding has led to a recent move to apply the theoretical construct of *frames of reference* (FoRs) from the domain of space to time, leading to sophisticated taxonomies for temporal frames of reference (e.g., Bender et al. 2010; Tenbrink 2011; Zinken 2010). The present paper argues that while space is important for modelling temporal reference, this is not the whole story. I argue that the experience types that in part underlie temporal representations are inherently temporal, rather than spatial in nature. They consist of a range of experience types, the hallmark of FoRs in the domain of time being *transience* (Galton 2011), a construct worked out in some detail. The present paper proposes three distinct types of *temporal frames of reference* (t-FoRs), anchored to three distinct types of transience. These proposals are argued to complement and enhance existing proposals for t-FoRs, rather than replacing them.

Keywords: temporal reference, time, space, transience, frames of reference, temporal frames of reference (t-FoRs)

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1 Introduction

Research over the last four decades has established that representations for time appear to recruit structure from representations for space. This conclusion, based initially on linguistic data (e.g., Clark 1973; Lakoff and Johnson 1980, 1999; Moore 2006) has since been supported by converging evidence from psycholinguistic and psychophysical studies (e.g., Boroditsky 2000; Casasanto and Boroditsky 2008; McGlone and Harding 1998; Gentner et al. 2002). For instance, when we say: *The relationship lasted a* ***long*** *time*, representations for space appear to be automatically activated in order to facilitate our conceptualisation of a temporal notion.

In the light of this finding, recent research has begun to explore whether frames of reference (FoR) in the domain of space can be applied to representations for time. Indeed, the assumption has been that it is entirely possible, and indeed, desirable to map FoRs that are found in the spatial domain onto the temporal domain, as time is largely structured in terms of space (see in particular Bender et al. 2010; and Tenbrink 2011 for discussion along these lines). A FoR, as we shall see in more detail below, is a coordinate system that logically involves three coordinates. When we say:

(1) The ball is front of the tree

a spatial sentence such as this involves an understanding of an entity, *the ball*, a reference object, *the tree*, and a perspective point from which the scene is viewed. In analogous fashion, Zinken (2010), for instance, has argued that a temporal sentence such as the following:

(2) I ate the crisps before the match

involves a FoR in which related coordinates are employed in order to facilitate our conceptualisation of a temporal sequence in terms of spatial relationship.

The point of the present paper is not to take issue with the conclusion that space is often useful and, arguably, necessary to structure how we think about time. I assume that representations for space are often automatically activated when we use and construct representations for time, in language use and in temporal reasoning tasks. That said, the argument I present here is that this is not the whole story. To get to grips with how we conceptualise time, and in particular, how we construct temporal reference, we must, I argue, examine those aspects of temporal reference that are inalienably temporal, and consider what they are bringing to the mix. In other words, there are elements of FoRs in the domain of time which are distinct and distinguishable from FoRs in the domain of space. And in part, perhaps large part, this is a consequence of a difference in the underlying experience types that respectively structure our conceptualisations of time and space. I argue that the experience types that underlie, in part, temporal representations are inherently temporal, rather than spatial in nature. They consist of a range of experience types, the hallmark of FoRs in the domain of time being *transience* (Galton 2011), a construct I work out in some detail below. The aim of the present paper is to propose that transience is an additional notion that should be taken into account in theoretical models of *temporal frames of reference* (t-FoRs), and which has hitherto not been considered when examining temporal reference. As such, I anticipate that the present proposals will complement and thus enhance extant models of temporal reference (e.g., Bender et al. 2010; Tenbrink 2011; Zinken 2010), rather than necessarily replacing them. I hope to show that the inalienable nature of a t-FoR, transience, is an attribute of the domain of time, and quite distinct and distinguishable from space.

The paper is structured as follows. In the next section I argue that the representations for time are grounded in experience types that are distinct from those that ground space. Hence, I make the case for time and space being distinct and distinguishable. This paves the way, in section 3 for a comparison between time and space at the conceptual level. Section 3 also introduces and develops the notion of transience, which I argue is central to temporal reference. Section 4 introduces the notion of temporal relations. I argue for three distinct transience types, giving rise to three distinct types of temporal relation, and consequently three distinct t-FoRs. Section 5 then reviews previous approaches to T-FoRs, elaborating on what is still missing from those accounts. Section 6 provides an overview of the theoretical architecture for t-FoRs that incorporates the notions of transience and temporal relations developed. Section 7 then applies these proposals, providing a sketch of the three distinct t-FoRs being proposed: a deictic t-FoR, a sequential t-FoR and an extrinsic t-FoR. Finally, section 8 gives a summary of the main proposals presented.

2 The nature of temporal representation

In this section I present reasons for thinking that concepts for time (temporal representation) are grounded in temporal experience types that are directly experienced (independently of spatial experience, and spatial representation). I argue that temporal representations accrue from phenomenologically real and hence perceivable experience types. Moreover, these experience types are associated with specific brain structures, and are complex and multifaceted in nature.[1] This discussion will begin to clear the way for the development of a theoretical account of t-FoRs later in the paper.

2.1 Starting points

The starting point for my approach to temporal reference is the approach to time in Conceptual Metaphor Theory, as represented in the work of Lakoff and Johnson

1 This claim does not preclude, of course, the view that temporal representation also recruits structure from spatial representation.

(1980, 1999), and the seminal work of Grady (1997), and especially Moore (2000, 2006, 2011).

Lakoff and Johnson (1999) argue that time is grounded in human perceptuo-motor experience of moving around in the world and of perceiving objects moving in the world. More specifically, Lakoff and Johnson claim that our experience of time arises largely by virtue of a metaphorical understanding of sensory-motor experience, especially motion events. They describe the situation as follows: "Very little of our understanding of time is purely temporal. Most of our understanding of time is a metaphorical understanding of motion in space." (1999: 139).

Lakoff and Johnson provide primarily linguistic evidence for this claim, the following being representative of the range of examples deployed:

(3) a. The time for action has passed
b. The deadline is approaching

(4) a. We're approaching the summer sales
b. We're moving towards decision-time

In the examples in (3), time is conceptualised in terms of motion of an object through space: time is moving, much like an object would. In (4), time is conceptualised in terms of a human observer, 'we', moving through space, towards a 'time', conceived as a static location. An important aspect of the claim made by Lakoff and Johnson is that the metaphoric structuring is typically asymmetric: while time is structured in terms of space, the reverse doesn't typically follow. In short, temporal representation is in part, perhaps large part, a consequence of structuring concepts for time in terms of concepts for space, and motion through space – concepts for space and motion through space being grounded in sensory-motor experience.

There is now a body of behavioural evidence which is compatible with this thesis. Evidence for the psychological reality of Time is Space conceptual metaphors comes from the work of McGlone and Harding (1998) and Gentner et al. (2002). McGlone and Harding found that an ambiguous temporal question would be answered in a prime consistent way if subjects were primed with either a Moving Ego or Moving Time version of a temporal conceptual metaphor. Similarly, Gentner and colleagues found that in a reading comprehension task, temporal conceptual metaphors primed for faster comprehension when the prime and target sentences were consistent.

Important psycholinguistic research by Boroditsky (e.g., 2000; Boroditsky and Ramscar 2002) investigated the claim that the relationship between spatial and temporal representations is asymmetric. Boroditsky found that temporal cues *do not* prime for spatial reasoning, while spatial cues *do* prime for temporal reasoning. In more recent research Casasanto and Boroditsky (2008), using psychophysical tasks, found a similar effect: space cannot be ignored when reasoning about time, and indeed seems to influence temporal reasoning. In contrast, temporal information appears not to influence spatial reasoning, to nearly the same degree.

That all said, representations of time must, presumably, be grounded in interoceptive experience types which are, at least in part, purely temporal (Evans 2004; Grady 1997; Moore 2006; Tenbrink 2007; Wallington 2012). For one thing, there must logically be something that is temporal for spatial representations to be mapped onto. And indeed, this is the view developed by others in the conceptual metaphor tradition, notably Grady (1997), Moore (e.g., 2006), and Wallington (2012). In the remainder of this section I substantiate this assertion.

2.2 Time is directly experienced

There is a very large body of evidence, from various branches of psychology, demonstrating the following: not only is time directly experienced, its manifestation is often independent of our experience of motion events in space.

Research on the perception of time, which has a venerable tradition dating back to the 19th century, reveals that we do indeed directly perceive time in interoceptive fashion. Moreover, the human experience of time is, in principle, distinct from our sensory-motor experience (of the external world). For instance, Flaherty (1999) has found that our perception of duration is a function of how familiar subjects are with particular tasks: training can influence our experience of task duration. Ornstein ([1969]/1997) has demonstrated that the complexity of a given perceptual array influences perception of duration. And Zakay and Block (1997) found that temporal perception is influenced by how interesting a particular activity is judged to be, or whether we are paying attention to a particular activity, which suggests that working and short term memory are implicated in our experience of time (Zakay and Block 2004).

Other research reveals that our ability to judge duration is a consequence of physiological mechanisms, which vary in inter-subjectively predictable ways. For instance, if vital functioning is accelerated by the consumption of stimulants such as amphetamines, or due to increased body temperature, this results in an overestimation of time amongst subjects (Hoagland 1933; Fraisse 1963, 1984). That is, time appears to proceed more quickly than usual. In contrast, reduced body temperature leads to an underestimation of time (Baddeley 1966): time appears to proceed more slowly than usual. In general, an increase or decrease in vital function consistently leads to overestimations and overestimations of time respectively (see Wearden and Penton-Voak 1995 for review).

Moreover, Flaherty (1999) has found that the nature of experience types can influence our experience of time. For instance, the phenomenon of *protracted duration* – the phenomenologically real and vivid experience that time is proceeding more slowly than usual appears to be a consequence of events including boredom and near death experiences (see Evans 2004, In press). In contrast, routine tasks with which we are familiar can give rise to the opposite effect: temporal compression – the phenomenologically real experience that time is proceeding more quickly than usual.

In addition, drive states such as moods and emotions influence our experience and perception of time (Droit-Volet and Meck 2007; Noulhiane et al. 2007; Wittmann et al. 2006; Wittmann 2009). Moreover, both personality and lifestyle appear to be implicated in our experience of time (Rammsayer 1997). For instance, Duffy and Feist (To appear) found that responses to a temporal reasoning task were influenced by how much control subjects had over their daily schedules, and whether they were an introvert or extrovert. In response to the following ambiguous question: 'The meeting on Wednesday has been moved forward two days. Which day is it now on?' Duffy and Feist found that extroverts and those whose lifestyle gave them greater freedom over their schedules tended to answer Friday. Introverts, and those with less freedom over their daily schedules, tended to answer Monday. Taken together, these findings appear to suggest that our experience of time is directly perceived in interoceptive fashion. Moreover, it appears to be a consequence of a variety of factors, ranging from cognitive function, to personality, lifestyle and momentary mood states.

Returning to language, it is clear that time is frequently encoded in its own temporal terms, both in lexis and in the grammatical system. For instance, English terms such as *yesterday*, *now*, *since*, *while*, *yet*, *soon*, *later*, *always*, *never*, and a raft of others lexicalise distinct types of temporal lexical concepts. Grammatical systems such as tense, aspect, and modality encode different types of temporal notions in many of the world's languages. Moreover, time-specific language, both in terms of lexis and grammar appear to consistently precede the acquisition of space-to-time metaphors cross-linguistically (Nelson 1996).

2.3 Time is not a monolithic experience type

Time, as experienced, appears to relate to a complex and multifaceted set of experiences. The neuroscientist Ernst Pöppel (1978) has argued that the human experience of time is made up of a number of quite different experience types. A subset of these, what he refers to as 'elementary time experiences' appear to be fundamental and have some claim to resulting from hard-wired neurobiological processes. These include our ability to perceive an elapse of duration, the ability to perceive simultaneity of events, the ability to perceive non-simultaneity, the ability to perceive succession (or event order), the ability to perceive the present and distinguish it from events that are set in the past, and the ability to perceive change. Indeed, a number of specific brain structures are now known to be implicated in several of these abilities, as discussed later.

Behavioural findings provide evidence that these elementary time experiences are directly perceived, and appear to be distinct, or at least distinguishable. The experience of the present is vividly distinct from recollections of the past and anticipations of the future. Human subjects reliably experience duration in broadly similar ways, and can reliably evaluate the durational elapse of events (see Wearden and Penton-Voak 1995).

Linguistic evidence would appear to support this view – if we make the (presumably reasonable) assumption that diversity in the linguistic encoding of time reflects, ultimately, diversity in types of temporal experience (Evans 2004; Grady 1997; Moore 2006). For instance, the English word *time* covers a range of quite different lexical concepts (Evans 2004). Consider the following examples:

(5) a. The time for action has arrived
    b. The time to start thinking about irreversible environmental decay is here [Lakoff and Johnson 1999: 143]

(6) a. Time flies when you're having fun
    b. Time drags when you have nothing to do

(7) a. The young woman's time [= labour/child-birth] approached
    b. His time [= death] had come
    c. Arsenal saved face with an Ian Wright leveller five minutes from time [BNC]

(8) a. [T]ime, of itself, and from its own nature, flows equably without relation to anything external [Sir Isaac Newton]
    b. Time flows on forever

In these sets of examples, all involving the form *time*, a different reading is obtained. In (5), a discrete temporal point or moment is designated, without reference to its duration. In (5a) the moment designated relates to the point at which a particular agent should act. In (5b) the designated moment concerns the point at which environmental issues should be considered. The examples in (6) provide a reading relating to what might be described as 'magnitude of duration'. For instance, (6a) relates to the phenomenologically real experience whereby time proceeds ‘more quickly’ than usual – the duration, while objectively constant, as measured, for instance, against a clock, ‘feels’ as if it is less than it actually is. This constitutes the phenomenon of *temporal compression* (Flaherty 1999). The example in (6b) relates to the experience of time proceeding ‘more slowly’ than usual – the duration ‘feels’ as if it is more than it actually is. This relates to the phenomenon of protracted duration, also discussed briefly above. In (7), the readings relating to *time* concern an event. In (7a) the event relates to the onset of child-birth while in (7b) the event designated relates to death. The event in (7c) concerns the referee blowing the whistle signalling the end of a game of soccer. In the sentences in (8) *time* prompts for an entity which is infinite as in (8a), and hence eternal as in (8b). Thus, in (8) the reading relates to an entity which is unbounded in nature. In sum, what these examples demonstrate is that *time* relates to quite different types of experience – having a single word form provides the illusion of semantic unity (Evans 2009).

While English has one word for a range of (arguably) quite distinct experience types, other languages do not have a single word that covers all of this semantic territory. By way of example, recent research on the Amazonian language Amondawa reveals that there is no equivalent of the English word *time* in that language (Sinha et al. 2011). Moreover, even genetically related languages utilise distinct lexical items to describe the semantic territory covered by the single lexical form, *time*, in English.

French is a good example of this. While the lexical form *heure* (‘hour’) is used to describe the moment sense of *time*:

(9) C’est l’heure de manger
 ‘It’s time to eat’

some of the other senses for English *time* are covered by the form *temps* (‘time’). This can give rise to the myth that the lexical item *time* relates to a homogenous set of experiences. I will return, below, to the issue of what unifies the experience types that might be considered to be temporal, especially as they relate to temporal reference.

In terms of cognitive neuroscience, a wide range of studies now reveal that our experience of time is multifaceted, subjectively real, and a consequence of neurobiological mechanisms and physiological processes. The basal ganglia and cerebellum are implicated in fundamental timekeeping operations upon which the coordination of motor control is dependent (Harrington et al. 1998). Other neuroscientists have argued that temporal processing is widely distributed across brain structures being intrinsic to neural function (e.g., Mauk and Buonomana 2004), and is fundamental to cognitive function (Varela 1999). Indeed, the emerging view from neuroscientific research on temporal processing is that the exquisitely sophisticated timing structures in the brain are key to a raft of fundamental neurological functions such as motor control and perception and may provide the cognitive 'glue' that facilitates learning and memory, behaviour planning, awareness, imagination and creativity (Pöppel 2009; Pouthas and Perbal 2004; Rubia et al. 2009). Temporal processing also appears to be fundamental to distinctively human symbolic behaviours including speech (Chafe 1994), as well as music and poetry (Davies 1996; Turner and Pöppel 1983; cf. Wittmann and Pöppel 2000). In short, temporal processing is likely to play a role in virtually all aspects of cognitive function (Ivry and Spencer 2004). And in so doing, the highly distributed nature of temporal processing in the brain is likely to be a key contributor to the human awareness of time.

2.4 Time is not grounded in sensory-motor experience at the neurological level

In spite of the linguistic and behavioural evidence, there is scant evidence that temporal concepts are directly grounded in sensory-motor experience at the level of neurological activity. On the contrary, distinct temporal concepts appear to relate to temporal experience types associated with brain regions distinct from those responsible for sensory-motor processing (Kranjec and Chatterjee 2010; Kranjec et al. 2012).

One aspect of temporal perception relates to our felt sense of duration. While the brain has a wide array of time-keeping mechanisms, in general terms, duration at sub-second intervals appears to be processed in specific subcortical regions. In contrast, temporal intervals at the supra-second interval, up to an outer limit of around three seconds, are processed in cortical regions. Timing mechanisms that underlie larger-scale circadian rhythms, including the so-called 'master' circadian rhythm – the wake-sleep cycle – are located in the suprachiasmatic nucleus of the hypothalamus (Buhusi and Meck 2005). In terms of sub-second timing mechanisms, the cerebellum and basal ganglia are strongly implicated. The processing of motor and perceptual components at the supra-second level involves areas including the supplementary motor area, and left inferior frontal and superior temporal cortical structures (Wiener et al. 2010).

In addition, duration processing dissociates with that for processing of sequence information at the neurological level. Ordinal sequence judgements appear to be made in premotor cortical areas, distinct from the areas involved in duration processing (Schubotz and Von Cramen 2001). Moreover, the brain region which stores the sequence of a motor response involves the right parietal cortex.

In contrast, durational information associated with the same task is stored in the cerebellum (Sakai et al. 2002).

There is also evidence that the distinct experience types involving our experience of the present, and thinking about the future and past, are associated with distinct brain regions. Pöppel (2004, 2009) argues that the human experience of the present derives from the distributed neurological processes that give rise to the so-called *perceptual moment*. The perceptual moment provides a temporal window with an outer limit of between 2–3 seconds, within which perceptual information is integrated. In short, it provides a temporal unit which serves to update the stimuli we perceive, and are consciously aware of.

In addition to our experience of the present, there is evidence that distinct brain regions are involved in thinking about the past and future. It has long been held that being able to think about the future is contingent on our ability to remember the past (Ingvar 1985; Tulving 1983, 1985). Recent data from neuroimaging studies supports the view that the same areas of the brain involved in recalling past events are also involved in thinking about the future (Addis et al. 2007; Botzung et al. 2008; Okuda et al. 2003; Szpunar et al. 2007). Episodic memories appear to involve a number of subcomponents. These include elements such as the retrieval of the subjective experience of duration, the multimodal elements of memory, and where relevant, the narrative structure of the memory (Hassabis et al. 2007). Episodic past thinking is hypothesised to involve the simulation of past events (Gilbert and Wilson 2007). Anticipated events are pre-experienced by virtue of simulations constructed based on past memories. In other words, past experiences are constructed, rather than being re-produced. And a similar process underlies pre-experience of the future (Schacter et al. 1998; Schacter and Addis 2007).

The brain regions implicated in thinking about the past and future appear to involve a "core system" (Abraham et al. 2008) centred on the medial prefrontal cortex, the medial parietal cortex, lateral inferior parietal cortex and medial temporal lobe structures (Schacter et al. 2007). Whilst not strictly speaking perceptual, it nevertheless seems to be the case that the basis for thinking about the past and future is grounded in brain regions that dissociate from those directly associated with sensory-motor processing.

Finally, it is worth briefly reviewing a study presented in Kemmerer (2005). Kemmerer provides evidence for a double dissociation between the processing of temporal and spatial meanings of English prepositions. For instance, the preposition *at* has a spatial lexical concept associated with it (e.g., *at the bus stop*) and a temporal lexical concept (e.g., *at 1.30pm*). In tests on four brain-damaged patients with lesions in the left perisylvian region, Kemmerer found the following. Two of the patients could correctly process the spatial lexical concepts of the preposition but not the temporal lexical concepts. In contrast, two of the patients could correctly process the temporal but not the spatial lexical concepts. This provides a line of evidence that the temporal and spatial representations that underlie language can be, in principle, dissociated at the neurological level.

In sum, the findings briefly reviewed in this sub-section appear to suggest that there are a number of distinct types of temporal experience. Moreover, these experience types appear to be associated with distinct brain regions and processes, and moreover, are not associated with those involved in the processing of sensory-motor experience. In short, at the neurological level, time appears to be, at least in principle, distinct from space, and motion through space.

2.5 Time as an intellectual achievement

The type of temporal representations I have been discussing thus far, such as duration, succession, present, past, future and so on, are grounded in direct experience of an array of temporal experience types. In addition, there is a type of temporal representation that appears not to be grounded in experiences of this kind. Representations of this latter type presume the existence of an objectively-real substrate that can be physically measured or observed, in some sense. One example of this is the *matrix* conceptualisation of time (Evans 2004), more recently referred to as 'time-as-such' (Sinha et al. 2011).

This concerns our understanding of time as a manifold which constitutes the whole of history: *the* event within which all other events take place. This view of time is exemplified by the linguistic example in (10):

(10) Time flows on (forever)

From this perspective it makes sense to talk of time as having a beginning, as if it were an entity that lies outside us, in some sense providing reality with structure. It is this Matrix conceptualisation that is implicit in the conception of time in post-Einsteinian physics. And by virtue of time as a Matrix thereby constituting an ontological category independently of events, we can discuss and study it, and describe its 'history', as evidenced by Steven Hawking's book: *A Brief History of Time*.

In the western philosophical tradition going back to at least Leibniz, it has sometimes been argued that time doesn't in fact exist as a thing unto itself (see Turetzky 1998, for discussion). Such a view appears to deny the existence of a subjectively real set of experiences that underlie our representation(s) of time. Instead, what is privileged is a putative objective reality of time, as if it were something external to us that, in principle, can be discovered. While various conceptions of time undoubtedly do exist as intellectual feats, arising from complex integration networks as described by Fauconnier and Turner (2008) – including, for instance, time-reckoning – there can be no doubt that we also directly experience time at the phenomenological level. Representations of time as intellectual feats arise precisely because a myriad of distinct types of temporal experiences inhere at the level of subjective experience, and can be represented in our conceptual systems and in language.

3 Time versus Space

In this section I compare and contrast time and space. I argue that our representations of these two domains, especially as exemplified in language, are quite distinct. I then introduce the notion of transience (Galton 2011), a feature of time that is absent from space (cf. Tenbrink 2007). I argue that transience is the hallmark of temporal reference.

3.1 Parameters for comparing time and space

In recent work, Galton (2011) has proposed a number of parameters that allow representations for time and space to be compared and contrasted. The finding that emerges from this research is that time and space are both qualitatively distinct conceptual domains. The relevant parameters that allow the two domains to be compared are: *magnitude*,[2] *dimensionality*,[3] and *directedness* (Galton 2011). I consider and nuance each of these parameters in turn.

MAGNITUDE

The parameter of magnitude relates to the quantifiability of a given *substrate* – the stuff that makes up the domain. The substrate the makes up space is *matter*, of which two broad types can be distinguished: discrete entities (e.g., objects) and mass entities (e.g., fluids). This distinction, in types of matter, is reflected in the grammatical organisation of many languages, whereby a distinction between count versus mass nouns is encoded. This is exemplified with the following examples from English:

2 Galton (2011) uses the term ‘extension’.
3 Galton (2011) uses the term ‘linearity’.

(11) a. A desk is useful for writing
b. *Desk is made of wood
c. *Some desk can be used to store stationery
(12) a. *A water covers three quarters of the planet
b. Water is constituted by the chemicals hydrogen and oxygen
c. Some water every day is good for your health

In addition, the substrate that makes up a domain exhibits a particular property allowing the substrate to be quantified: the way in which the substrate can be 'cut up' into 'amounts'. The amounts, in the domain of space, relate to the property *extension*. Extension manifests itself in three distinct types – which is a function of the three-dimensionality of space, discussed further below. Space's extension involves length (one dimension), area (two dimensions), and volume (three dimensions).

The substrate that makes up time, at least as reflected in language, is that of *action* (Talmy 2000). As with space, action can also be broadly subdivided. This relates to whether action is *bounded* versus *unbounded*, analogous to the distinction between discrete versus mass for the substrate matter. This is illustrated by the grammatical distinction between perfective versus imperfective aspect:

(13) John ran [perfective]
(14) John was running [imperfective]

In the domain of time, the property exhibited by action, and hence, the means of 'cutting up' action in amounts is *duration*, rather than extension. While duration can, self-evidently, be quantified by using *measurement systems* involving material artefacts such as clocks, duration (of relatively shorts periods) can be estimated without the need for measurement systems such as these. Indeed, human subjects appear to be able to reliably distinguish between periods of different temporal magnitudes (i.e., duration). Moreover, and unlike the property of extension exhibited by spatial substrate, there is only one dimension with respect to which temporal substrate is quantified, to be discussed below. The distinctions between space and time in terms of the parameter of magnitude are summarised in Table 1.

DIMENSIONALITY

Dimensionality, in physical terms, relates to the *constitutent structure* of matter. The constituent structure of matter involves three distinct planes with respect to which points can be located. These are the transversal (left/right), sagittal (front/

Table 1: Comparing the parameter magnitude for space and time

Domain	Space	Time
Substrate	Matter	Action
Property	Extension	Duration
Distinction	Discrete vs. mass	Bounded vs. Unbounded

back) and vertical (up/down) planes. Hence, our everyday representation of space can be said to be three dimensional.

In contrast, in the domain of time the constituent structure of action involves *succession*: the sequential relationship that holds between distinct units and subunits of action. In other words, our representation for time involves a relationship between units of action in a sequence. This involves just one dimension.

Physical theories that incorporate time, such as in the Theory of General Relativity (Einstein 1916), treat time as the fourth dimension of space, forming a space-time continuum. On this view, points can be 'located' in time, where units of action are strung out, all at once, across time. Yet this view is at odds with the human phenomenological experience of time (see Evans 2004: Chapter 19). In so far as time, from a phenomenological perspective, can be said to exhibit dimensionality, this relates to the sequential relationship between events, providing one-dimensional constituent structure.

DIRECTEDNESS

The final parameter, directedness, relates to whether the substrate in a given domain is *symmetric* (i.e., isotropic) or *asymmetric* (i.e., anisotropic). Space is isotropic: it has no inherent asymmetry. Indeed, it is possible to proceed in any direction: forward or back, or from side to side.[4] In contrast, time is anisotropic: it manifests asymmetric organisation. One of the most celebrated forms of anisotropy, in the domain of time, relates to the thermodynamic property of matter, exhibited by the dispersal of energy (entropy): all things being equal a cup of coffee cools down, and cannot subsequently and spontaneously heat up again. The anisotropic nature of time, particularly at the macroscopic level of matter, led

4 While space has no inherent asymmetry, Galton (2011) points out that some directions in space do nevertheless exhibit asymmetry. For instance, the vertical plane is asymmetric by virtue of the gravitational pull of the Earth, which provides an asymmetry between up versus down. Analogously, there is an asymmetry between North and South, a consequence of the magnetic core of the Earth.

the British astrophysicist, Sir Arthur Eddington (1928), to coin the term 'the arrow of time' (see also Coveney and Highfield 1991; see also Le Poidevin 2003). That said, from the phenomenological perspective, time is experienced as anisotropic at the subjective level. This concerns the anticipation of a future event, the actual experience of the event, and finally, the recollection of the event as past. This feature of time I refer to as *anisotropicity*.

2.2 Transience

In his work, Galton (2011) discusses an additional feature which he argues is exhibited by time, but not by space. This he refers to as *transience*. It is worth quoting Galton at length to give a sense of this:

> [Transience is] difficult to describe without lapsing into circularity. There are many common phrases which successfully conjure up the feelings engendered by this mysterious notion, without however going any way towards explaining it, phrases such as ''Here today, gone tomorrow'', ''You only live once'', ''Time and tide wait for no man''. In an attempt to spell out more precisely what is meant, we might say such things as: we only experience a time at the time we are experiencing it; a given moment only occurs once, fleetingly, at that very moment; a given time is only present when it is that time. But arguably these are no better (and in many respects worse) than the common phrases listed earlier. Like them, they may successfully convey to us a feeling for what is meant by transience, but only because in some sense we already know what it is. It seems impossible to explain this notion, to describe it in a way that would enable someone unfamiliar with it to understand. (2011: 698)

For Galton, transience is the hallmark of time, and hence part of its inalienable character. Tellingly, he observes that the metaphors that facilitate the recruitment of inferential structure from the domain of space to flesh out temporal representations in fact draw, in circular fashion, on temporal transience to do so:

> All metaphors for temporal transience take some kind of change as their source, and hence themselves depend on temporal transience. We cannot describe this aspect of time without lapsing into circularity. Hence time, in its transient aspect, has a *sui generis* character that cannot be captured by metaphors that do not make use of the very notion to be described: time, as a fundamental and inalienable feature of our experience, will ultimately resist our attempts to explain it in terms of anything else. (2011: 695)

In the remainder of this section, I develop and extend this notion of transience, and argue that it forms part of a more complex set of temporal experiences, which ground distinct types of temporal representation.

As a first pass at beginning to specify this notion of transience, I offer the following nuanced definition:

(15) Transience is the subjectively felt *experience* of (temporal) passage

In (15), 'passage' refers to our subjective experience of time, rather than motion, i.e., physical passage. Subjective temporal passage arises from events of various sorts. These include activities (e.g., a morning jog), when we perceive or experience an event (e.g., watching a movie), or experience, or are conscious of a specific state, (e.g., fatigue, hunger, love, and so forth).

In addition, I argue that transience, like the larger domain of time which subsumes it, is itself not a monolithic temporal representation. I suggest that there are three types of transience, which relate to the three parameters which can be deployed to compare time and space. These transience types are duration, succession, and anisotropicity. Duration concerns the felt experience of the passage constituting an elapse – something greater than the perceptual moment (with an outer limit of around 3 seconds). Succession concerns the felt experience of the passage involving earlier and later experience types, which are sequenced with respect to each other. And anisotropicity concerns the felt experience that the passage exhibits inherent asymmetry – a felt distinction between future, present and past. Table 2 summarises these transience types.

Table 2: Transience types

Transience type	Description
Duration	the felt experience of the passage constituting an elapse
Succession	the felt experience of the passage involving earlier and later experience types
Anisotropicity	the felt experience that the passage exhibits inherent asymmetry – a felt distinction between future, present and past

The relationship between the three transience types, and the parameters which relate to space and time, are captured in Figure 1. The striking feature, then, of temporal experience is, in fact, less a discrete feature of time, but a consequence of the cumulative effect of the three parameters described above. Transience arises from temporal magnitude, which is to say duration, in conjunction with the sequential dimension of time, in which events form a sequence, with earlier events preceding later ones, combined with the anisotropic nature of time, which relates to the distinction between future and past tied to the deictic experience of the present.

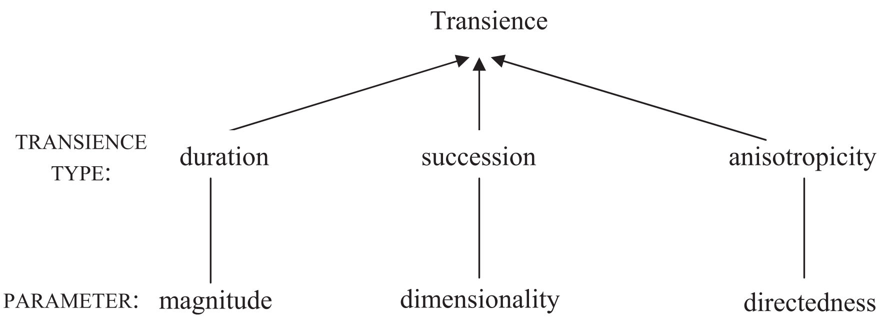

Fig. 1: Types of transience and their parameters

The domain of time, as observed, is multifaceted. Transience types logically support more complex experience types. These I refer to as *temporal qualities*. Temporal qualities are experience types that involve comparison with respect to transience. In other words, temporal experiences of this sort involve a comparison across a specific type of transience. Examples of temporal qualities include frequency, change and synchronicity. Change, for instance, involves a comparison, or awareness of a difference between two states at different temporal intervals, and hence, is processed with respect to transience. Frequency involves the identification of a number of iterations of experiences, or experience types at different temporal intervals. And synchronicity involves an awareness of two experiences or experience types occurring at the same temporal moment (see Table 3).

There is a further class of temporal experience types: what I refer to as *temporal elements*. These are phenomenologically simple experience types that contribute to – or in some cases arise from – our experience of transience. These include felt experience types such as now, past, future, earlier and later. These are temporal elements in the sense that they are, in phenomenological terms, simpler than either temporal qualities or transience types. Indeed, in terms of complexity, temporal qualities are the most phenomenologically complex temporal experience

Table 3: Temporal qualities

Temporal quality	**Description**
Change	a comparison, or awareness of a difference between two states at different temporal intervals
Frequency	the identification of a number of iterations of experiences, or experience types at different temporal intervals
Synchronicity	an awareness of two experiences or experience types occurring at the same temporal moment

type, followed by transience types, with temporal elements being the most phenomenologically simple.

The central claim of the remainder of this paper is this: temporal reference relates to transience; the function of temporal reference systems is to fix an event in time, which is to say, with respect to the transient nature of time. I shall argue that the three t-FoRs to be briefly described provide distinct strategies for fixing events with respect to the three distinct types of transience identified.

4 Temporal relations

In this section I make the case for the construct of *temporal relations*. These, I shall argue, arise from distinct transience types. And as each t-FoR is grounded in a specific transience type, each t-FoR accordingly gives rise to a distinct temporal relation.

It has long been noted by philosophers that time is conceptualised and lexicalised in terms of motion in space. Smart (1949), for instance, described two metaphorical conceptions for time, in which time is conceived in terms of motion towards an observer, or an observer's motion towards the future. In relatively recent times this observation has been taken up by psychologists and linguists. In characteristically insightful work, Clark (1973) modelled this distinction in terms of a divergence in *perspectives*, paving the way for the contemporary study of temporal reference. Clark distinguished between the Moving Ego (ME) and Moving Time (MT) perspectives of temporal conceptualisation:

(16) a. Christmas is approaching 'Moving Ego'
b. We are approaching Christmas 'Moving Time'

The distinction between ME and MT space-to-time motion models was formalised by Lakoff and Johnson (1980, 1999) as figure-ground reversals of the more general TIME PASSING IS MOTION CONCEPTUAL conceptual metaphor (Lakoff 1993).

In more recent work, Moore (2000, 2006) has convincingly argued that, in addition to the ME and MT perspectives, there is a conceptualisation of time which is sequential in nature. Building on insights by Traugott (1978), Moore points out that in an example such as (17), time is conceptualised not in terms of an egocentric perspective-point, but rather, as being sequential in nature:

(17) Christmas comes before New Year's Eve

Moore's work is important in at least two ways. Previous research, both within and outside the conceptual metaphor tradition, while acknowledging the importance of perspective in conceptualisations of time, hadn't stressed it to the degree found in Moore's work. Moore, arguably for the first time in contemporary research, refers to 'reference frames' in order to describe space-to-time motion ascriptions.

Secondly, Moore introduces an important notion into the literature, that of 'temporal relation' (although Moore doesn't specifically use this term). In essence, Moore observes that the distinction between the examples in (16) and (17) is that the former denotes a *future/past relation*. This relates to, and arises from, what I have dubbed anisotropic transience: this temporal relation is a consequence of the type of transience arising from the phenomenologically real experience of a present which is ceaselessly updated. In contrast, the example in (17), according to Moore, denotes an *earlier/later relation*. This relation is grounded in the transience type: succession. After all, a salient feature of event sequences is the earlier/later relationship holding between two given events in the sequence.

Moore further observes that these distinct temporal relations – future/past and earlier/later – have different reference points (RP). In the examples in (16) the RP is the ego – the human egocentric experience of now – or more precisely the location here, which metaphorically corresponds to now, a distinction that is important as we shall see later. Christmas is conceptualised by virtue of whether it is set in the future or the past with respect to the ego. In (17), in contrast, the RP is not the ego, but rather an event, New Year's Eve, which serves to fix Christmas in time.

In addition to future/past and the earlier/later temporal relations, a third temporal relation suggests itself. This concerns the relation in which time constitutes *the* event in which all others occur, which is to say, the Matrix conception of time. In essence, this constitutes a bounding relation which subsumes the beginning and ending of all of existence. Just as the future/past relation arises from anisotropic transience, and the earlier/later relation arises from succession, the matrix relation arises, I suggest, from durational transience.

That said, the matrix relation is somewhat different from the previous two. Firstly, the future/past and earlier/later temporal relations appear to be grounded in phenomenologically real experience types. As I noted earlier, the matrix relation is not grounded in phenomenologically real experience. After all, the matrix relation concerns an elapse that is eternal in nature. Yet, as human life is clearly not eternal, it stands to reason that the matrix relation, while grounded in the transience type duration, must emerge from the prior conceptualisation of duration as an ontological category reified as an entity independent from the substrate that makes up the domain of time. In other words, the matrix relation emerges from a reified version of duration, conceived as being independent of events and available as a category for inter-subjective reflection in its own right.

Kranjec (2006) has provided suggestive behavioural evidence for thinking that there is a temporal reference strategy, what he dubs extrinsic, in which time is conceived as a field providing events with an 'extrinsic' frame of reference. My proposal is that this field arises from durational transience, and the temporal relation involved is the matrix relation. Table 4 summarises the distinct types of transience, the temporal relations involved and the reference strategies that emerge.

Table 4: Temporal relations

Type of transience	Temporal relation	Name of t-FoR
Anisotropicity	Future/past	Deictic
Succession	Earlier/later	Sequential
Duration	Matrix	Extrinsic

5 Previous approaches to temporal frames of reference (t-FoRs)

Spatial frames of reference (s-FoRs) logically involve three coordinates (e.g., Levinson 2003; see Tenbrink 2011, and Zinken 2010 for discussion). These are as follows:

- *figure* (F): which is the entity being located,
- *reference object* (RO), the entity which serves to locate F, and
- *origo* (O): the entity which fixes the coordinate system of the RO, thereby establishing the search region

For instance, consider the relative frame of reference (in Levinson's 2003 parlance). To illustrate, consider Figure 2.

The relative frame of reference is exemplified by the following examples:

(18) a. The cat is in front of the tree
b. The dog is on the right side of the tree

In order to locate the F, in these examples, the cat and dog respectively, a search domain must be established. This is achieved using the RO, the tree. However, as

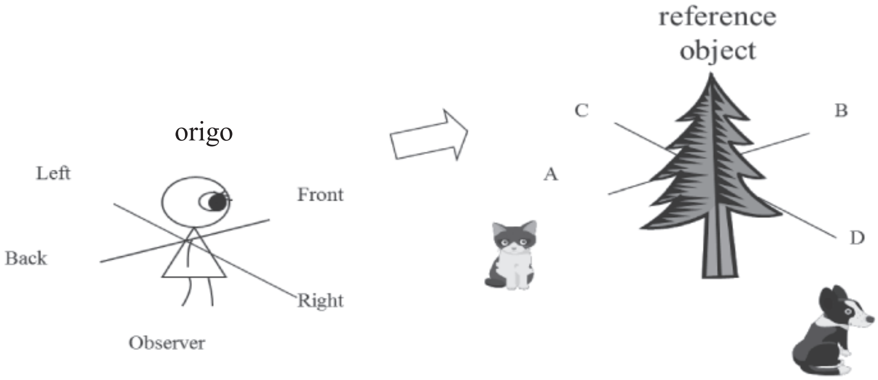

Fig. 2: Relative s-FoR (Adapted from Shinohara and Matsunaka 2010: 296)

the RO, the tree, has no inherent asymmetry, it has no inherent coordinate system that can be deployed to establish the search region. In the relative FoR, the coordinate system derives from the observer, which thus constitutes the O of the coordinate system. In Figure 2, the left/right, front/back axis of the observer is projected onto the tree, the C/D, and A/B coordinates respectively of the tree, in Figure 2. The FoR is relative in the sense that it is relative to the observer, and the observer's location. And once the RO has been anchored to the observer's coordinate system, it is then possible to locate the F with respect to the RO, the tree. The cat is in front of the tree because the tree – in English – reflects the inherent asymmetry of the observer.

Seminal research on temporal reference, notably Moore (2000, 2006) and Núñez and Sweetser (2006), introduced the notion of a temporal reference point (RP), as discussed earlier. This innovation allowed researchers to successfully distinguish between deictic and sequential reference. However, in important work, Zinken (2010) observes that positing a temporal RP nevertheless still doesn't fully account for temporal relations of the sort discussed above. This follows as temporal relations arise from a number of distinct coordinates, which have to be formalised in order to provide a descriptively adequate account. What was required, Zinken argued, was a theoretical approach to temporal reference that made use of the notion of a frame of reference (FoR): deploying the three coordinates logically required by such a theoretical construct (see also Bender et al. 2010 for related arguments).

More recent work, notably Bender et al. (2010) and Tenbrink (2011) sought to do exactly this. While the taxonomies diverge both in the approach taken and the complexity claimed, both approaches assume the following. First, it is possible, and indeed desirable to provide a unified approach to FoRs in the domains of space and time. Second, theoretical constructs for FoRs from the domain of space can be mapped onto time in order to understand time, despite the apparent differences between space and time. Bender et al. (2010) explain the rationale for this as follows:

> How far can we get in comparing the representational systems for space and time? The two domains differ in essential aspects: time extends in one dimension only, whereas space has three and, unlike space, time has a distinct direction, which is not reversible. Given these substantial differences, are spatial frames of reference applicable for temporal relations at all? We propose that it is indeed possible to map the former onto the latter because the directionality of time compensates for the deficiency in dimensions. (2010: 289).

Finally, both Bender et al. and Tenbrink make use of Levinson's framework in developing their approaches to t-FoRs, assuming that like space, FoRs in the domain of time can be divided into intrinsic, relative and absolute FoRs. Bender et al. are concerned with cross-linguistic variation. Tenbrink (2011) develops a taxonomy based exclusively on English; that said, Tenbrink's taxonomy is intended to be a language-independent conceptual framework for how languages express t-FoRs. Moreover, she impressively extends Levinson's taxonomy in the domain of space from static relations to also include dynamic spatial relations. Tenbrink then applies these insights to the domain of time.

One reason for seeking to map FoRs from the domain of space onto time is that language relating to space, as noted earlier, appears to be recruited when speaking and thinking about time. And, behavioural findings indicate, as also observed earlier, that spatial representations appear to be used, and moreover, automatically activated, when reasoning about time. Taken together, these findings make it reasonable to assume that FoRs in the domain of time should be largely space-like.

Tenbrink, for instance, identifies around ten distinct t-FoRs. These include sub-types of intrinsic, relative and absolute FoRs. But the criteria for classification relate to the nature of the spatial language used. For instance, consider the following example:

(19) Good times lie before me (Tenbrink 2011: 716)

This is classified as being a 'temporal static' variant of the intrinsic t-FoR. This follows as RP, the ego, and the 'relatum' (Tenbrink's term for the entity being 'located' in time) are static. It is an example of the intrinsic t-FoR as the third coordinate in Tenbrink's taxonomy, the perspective point, is coincident with the RP. That is, the perspective point is that of the ego, and hence, is making use of the

RP's intrinsic orientation: the RP is directed towards the relatum which lies in front of the RP/ego.

While a taxonomy of this kind makes a lot of sense, we have seen evidence that time is, in principle, distinct and distinguishable from space. Indeed, I suggest that transience is criterial for temporal reference and is wholly absent in spatial reference. In short, my claim is that while the work of Bender et al. and Tenbrink insightfully demonstrates the way in which spatial representation contributes to some aspects of temporal reference, what is still missing is the essence of what makes temporal reference temporal. After all, language users have no problem distinguishing between examples of the following kind:

(20) a. We're approaching Christmas
b. We're approaching London

And yet, presumably our understanding of the difference between the two expressions is due to more than simply representing temporal relations in terms of space – as in the work of Tenbrink (2007), and in the work of other researchers who study the way in which spatial representation is deployed to structure time – see especially Moore (e.g. 2006).

Indeed, on this very issue, recent work by Bender et al. (2012) casts doubt on their previously published taxonomy (Bender et al. 2010). In the 2012 paper, Bender and colleagues specifically sought to experimentally investigate the psychological validity of the following claim: FoRs from space are mapped onto temporal reference. In one behavioural experiment using English subjects, the experimenters made use of the expression 'move forward', which can relate to both the domains of space and time. In a spatial condition the experimenters examined which FoR was deployed (absolute, intrinsic or relative, in their terms, and based on Levinson's taxonomy). In a temporal condition, they examined which FoR speakers used the same expression – based on their 2010 taxonomy for t-FoRs, which, as noted earlier, applies Levinson's taxonomy from space to time. Their expectation was that, if s-FoRs map onto and structure t-FoRs, then time should pattern after space in terms of reference strategies.

However, their behavioural experiments, to their surprise, failed to support such a link. And the failure to map from space to time was also found to occur in languages other than English, notably German, Chinese and Tongan. It is worth quoting Bender et al. on this:

> The prime goal of this study was to examine whether the preferences for a specific FoR in spatial contexts would carry over to the temporal domain. Given the large body of research attesting to the link between space and time, we expected this to be the case (cf. Bender,

> Beller, & Bennardo, 2010). Our current findings, however, are rather discouraging in this regard. Not only did we find no correspondence between temporal and spatial references in the four languages under scrutiny, we did not even find a hint of correlation in the one case that was most promising, US-English. (Bender et al. 2012: 8–9)

The conclusion I draw from this discussion is this: while spatial representations do, in part, support and structure temporal representations, temporal reference is, nevertheless not an analogue of spatial reference. I sketch below an approach to t-FoRs that takes the notion of transience seriously.

In addition, the current research effort has a further motivation. The paradigm example of a t-FoR is a time measurement system: time measurement allows us to fix events in time, and thus provides, by definition, a temporal frame of reference. Two broad types of time measurement systems abound: event-reckoning systems (e.g., calendars) and time-reckoning systems (e.g., clocks). Moreover, we use complex language to describe the temporal relations that arise from such systems. For instance, an example such as "The time is approaching midnight" does not relate to deictic or sequential reference, but is something quite distinct, as is an example such as "Christmas has come round again". In what follows I develop a framework that facilitates a unified approach towards time measurement as well as sequential and deictic temporal reference. Indeed, one potential difficulty for extant taxonomies for t-FoRs is that, by utilising Levinson's distinction between intrinsic, relative and absolute FoRs, this blurs the distinction, in temporal reference, between sequential and deictic reference. Hence, the approach I take in the present work is to base my taxonomy around the reference strategies that appear to hold in the domain of time, deictic and sequential reference (Moore 2006; Núñez and Sweetser 2006), as well as extrinsic reference (Kranjec 2006; Kranjec and Chatterjee 2010). I posit sequential and deictic t-FoRs, and also argue for an extrinsic t-FoR which, I will propose, relates to time measurement.

The point of the foregoing discussion has not been to invalidate the value of examining the relationship between time and space, and the role of space in facilitating temporal reference. On the contrary, evidence from research within the framework of Conceptual Metaphor Theory, and the supporting work accruing from behavioural studies makes clear that spatial representation is recruited in order to support temporal representation. That said, my claim is that any account of temporal reference must additionally consider the issue of transience, which is that aspect of time which underpins our ability to experience, and hence fix events in time. Moreover, our experience of transience underpins our ability to represent temporal reference, including the use of spatial language and spatial representations in constructing and utilising t-FoRs.

6 The Nature of Temporal Frames of Reference (t-FoRs)

A t-FoR, as I conceive it, involves a coordinate system that gives rise to one of three types of temporal relation. A t-FoR identifies, or fixes, an event with respect to one of the three types of transience identified earlier, from which the temporal relation arises. In this section I present a detailed taxonomy of the three types of t-FoRs. My main line of evidence for this arises from a preliminary survey of expressions from English. Further investigation is clearly required, although see Evans (In press).

My assumption is that language provides reflexes of each of the three distinct t-FoRs. These take the form of sentence-level constructions involving motion ascriptions of particular kinds. What the motion ascriptions achieve is to encode a different kind of temporal relation, the hallmark, I suggest of a distinct t-FoR. In this section, I make proposals as to the main elements that make up a t-FoR, and how these relate to temporal relations, and reference strategies.

6.1 Coordinates employed in t-FoRs

A t-FoR, as encoded linguistically, makes use of a number of coordinates in order to identify an event with respect to a specific transience type. As such, it constitutes a *coordinate system*. There are three coordinates that appear to be required to describe a linguistically-encoded t-FoR:

– *target event* (TE): the event being fixed – this is the analogue of F in an s-FoR
– *reference point* (RP), which is an entity with respect to which the TE is fixed – this is the analogue of the RO in an s-FoR
– The *origo* (O), in a t-FoR, is the element that anchors the RP in one of the three transience types (duration, succession and anisotropicity) – this is the analogue of the O in an s-FoR.

To illustrate, consider the following, which minimally differs from (20a):

(21) We are fast approaching Christmas

In this example, the TE is Christmas, encoded by the form *Christmas*. This is the event being fixed. In addition to a TE, a t-FoR has an RP, with respect to which the TE is fixed. In the example, the RP is the location of the ego, encoded by *we*. A t-FoR also includes an O. This provides a means of anchoring the RP to the transience type that defines the specific t-FoR. In (21), the O is the egocentric experience of now, which constitutes the conscious experience of the present. As the ego's location correlates with the egocentric experience of now, this guarantees that the location of ego, which serves as the RP for identifying the TE, relates to a temporal – rather than a spatial – relation. In the example in (21) the temporal relation is future/past, anchored by the O, here the egocentric experience of now. By virtue of this, the TE, Christmas, is identified as being future-based with respect to the experience of transience. In other words, the metaphoric spatial relation, the relative approach of the experience with respect to a temporal landmark, can be used to 'compute' the temporal relation precisely because the O grounds the spatial relation in anisotropic transience: the temporal experience relevant here for fixing the event of Christmas. Put another way, the O, our experience of 'nowness', anchors the expression to our experience of anisotropicity: our experience of time as being asymmetric and hence future/past based.

Evidence for a disjunction between the constructs of an RP and an O, both of which are encoded by *we* in (21) follows from the following observation. The sentence encodes a *temporal scene* rather than a *spatial scene*. Sentence (21), despite employing the vehicle *approaching,* is not taken to refer to veridical motion, but rather, the relative imminence of Christmas: it concerns a temporal relation. For that to be the case there must be a means of fixing the TE, Christmas, with respect to the transience type that supports the temporal scene encoded by (21). The temporal relation that consequently arises – whether the TE is future- or past-based with respect to the RP – must be grounded by the egocentric experience of now, the O. If that were not the case, the experiencer's location (RP) relative to Christmas, could not be interpreted in temporal terms.

A previously unremarked observation relates to 'spatial' sentences that parallel (21). Consider (22) by way of example.

(22) We are fast approaching London

One key difference between (22) and (21) is that (22) conveys veridical motion, as it must if it is to be taken to encode a spatial, rather than a temporal scene. However, in certain other respects the examples in (22) and (21) are analogous. For instance, in (22) *we* encodes location on a path relative to the landmark, London, which is the entity being approached. However, a consequence of undergoing motion, which, as noted by Galton (2011) involves transience, is that the experiencer in (22) is also associated with the egocentric experience of now, which correlates with the experiencer's present location. In other words, in (22) London is located spatially ahead of the experiencer, *and* is situated in the future, given the experiencer's current apprehension of the present. Hence, what is common to both (22) and (21), and hence to both spatial and temporal scenes, is that there is a spatial location and an egocentric awareness of now associated with the experience, as encoded by *we*. Indeed, it is plausible that the reason relative motion constructions of the sort exemplified by (22) have been extended to temporal scenes as in (21) is precisely because there is a correlation in veridical motion between location and the experience of transience.[5] Table 5 presents a summary of the key terms, relating to coordinates employed in describing t-FoRs.

Table 5: Coordinates in t-FoRs

Coordinates	Description
Target event (TE)	The event, in a temporal scene, that is identified with respect to transience
Reference point (RP)	The point which is deployed to fix the TE
Origo (O)	The point that serves to ground the RP to the transience type that defines the t-FoR

6.2 Temporal reference strategies

In this section I consider other aspects central to a description of t-FoRs. This includes, notably, the notion of a reference strategy. As each t-FoR identifies a TE with respect to a distinct type of transience, this gives rise to a distinct *reference strategy:* a unique approach to fixing temporal reference.

Coordinate systems arise on the basis of how reference is fixed amongst the coordinates. In this respect, the relationship between the RP and O, which together serve to fix reference, and hence identify the TE, is criterial. Each of the three t-FoRs identified exhibits a distinct type of reference, the consequence of a distinct reference strategy.

The deictic t-FoR involves a coordinate system that is *egocentric*. This follows as it is the egocentric experience of now which anchors reference to the anisotropic transience type. This provides an *experiencer-based* reference strategy, as temporal reference derives from the human experience of the present. A linguistic example of this type of reference strategy is exemplified by (21).

5 In slightly different terms, Moore (2006) makes a related point with his discussion of the *grounding scenarios* for space-to-time motion metaphors.

In contrast, the sequential t-FoR involves an *allocentric* coordinate system – one that is other-based – rather than being based on the experiencer in question. This is the case as reference is facilitated by events in a sequence, which gives rise to an earlier/later temporal relation. Because of this, the reference strategy can be classified as *event-based*. An example of this type of reference strategy is exemplified by the example in (23):

(23) Christmas precedes New Year's Eve

In this example, the TE, Christmas is fixed with respect to an event-based reference strategy. This involves relating the position of Christmas to other events in a sequence, and specifically, New Year's Eve, with respect to which Christmas is earlier.

Finally, the extrinsic t-FoR is also allocentric; but rather than relating to events, it involves a *field-based* coordinate system. This follows as it provides a means of establishing an equably graduated field which anchors reference to a matrix – a conceptualisation of duration as an unending event in which all else occurs. The field is established by virtue of adopting a *periodicity-based* reference strategy. That is to say, reference is fixed by virtue of external periodicities – naturally recurring perceptual occurrences, of which there are many types – which can be measured in a variety of ways. Consider the following example:

(24) The time is approaching 11

In this example which relates to the 12 hour clock, a TE is identified. This is achieved by measuring the elapse associated with the periodic behaviour of a mechanical device (e.g., a watch), thereby relating the TE, the present moment, to the RP, which is the location of 11 on a clock 'face'.

Table 6 presents a summary of the different reference strategies and how they relate to other features of t-FoRs.

Table 6: Reference strategies and their relationship to t-FoRs

	Deictic t-FoR	Sequential t-FoR	Extrinsic t-FoR
Type of transience	Anisotropic	Succession	Duration
Temporal relation	Future/past	Earlier/later	Matrix
Type of coordinate system	Egocentric	Allocentric: events	Allocentric: field
Reference strategy	Experiencer-based	Event-based	Periodicity-based

7 Three temporal frames of reference

In this section I briefly present linguistic evidence from English which is consistent with the proposals made above.

7.1 The deictic t-FoR

In the deictic t-FoR, the O constitutes the egocentric experience of now, anchoring the system to the phenomenologically real experience of anisotropicity – the felt experience that the passage exhibits inherent asymmetry: a felt distinction between future, present and past. Indeed, it is this anchoring to our subjectively real experience of anisotropicity which is what makes this t-FoR deictic. One consequence of this is that the temporal relation captured by this t-FoR is a past/future relation.

That said, the linguistic evidence shows that the deictic t-FoR also makes use of spatial information as a representational medium, in computing the temporal relation holding between the target event (TE) and the O. That is, events are related to a physical reference point (RP). More specifically, they are configured with respect to the experiencer's location in three dimensional space. Hence, the RP in a deictic t-FoR is the experiencer's location, anchored by the experiencer's awareness of now, the O, which is coincident with the experiencer's precise location. Consider the following example:

(25) We are moving closer to Christmas

In this example, the TE is Christmas, the event being fixed with respect to the experience of anisotropic transience. Yet the way this is achieved is by relating the TE to a spatial RP, the experiencer encoded by *we*. But as the experiencer is coincident with the egocentric experience of now, the relative motion of the experiencer with respect to Christmas provides a means of computing the relative point in time of the TE with respect to the O. And in this way, the TE is fixed with respect to anisotropic transience, giving rise to a future relation, in this example. Hence, spatial information provides a means of supporting temporal reference in the deictic t-FoR.

Within this kind of t-FoR, events fixed as being in the future can be said to exhibit the property: *imminence*. Events that are fixed as being coincident with the experience of now can be said to exhibit *synchronicity*. Those that are fixed as being in the past, can be said to exhibit the property: *occurrence*. Hence, this t-FoR provides a means of fixing events that are very much grounded in the human experience of future/present/past, corresponding to the tri-fold distinction between current perceptual processing (present), memory (past) and anticipation (future) – see Gell (1992) for discussion. Consider examples illustrating these relations below:

'Imminence'
(26) Christmas is approaching
'Synchronicity'
(27) Christmas has arrived
'Occurrence'
(28) Christmas has gone

In each of these, there is a TE, *Christmas*. The RP is the experiencer's location, not explicitly encoded, but implicit in the deictic motion relation (e.g., *approaching vs. arrived vs. gone*). The claim I am making is that these examples are linguistic reflexes of the deictic t-FoR. To demonstrate that this is so, we need to exclude the possibility that these relations are due to tense.

While not all languages feature a morphologically bound tense system, many do. Tense morphologically encodes the time reference of an event, on the verb, with respect to coding time: the notion of when the utterance is being made. In so doing, tense is clearly a deictic phenomenon, and thus, ultimately, also related to the ability to form perceptual moments – as briefly discussed in section 2 above. While some languages exhibit reasonable complexity in terms of their tense systems – the most morphologically-bound tenses exhibited by a single language is eleven (Evans 2009) – a language such as English only features two (morphologically bound) tenses – present and past (or not now). Some languages, in contrast, don't encode tense, such as Mandarin. Examples of English tense are given below:

(29) John kicks the ball (present)
(30) John kicked the ball (past)

In order to conclude that the examples in (26) to (28) exhibit a deictic t-FoR, we must be able to demonstrate that the readings relating to imminence/synchronicity/occurrence are independent of tense. To do so, consider the following sentences:

(31) a. Christmas is getting close
b. Christmas is coming up
c. Christmas is drawing near

These sentences all appear to relate to the relative imminence of a specific TE – the occurrence of Christmas – with respect to an implicit RP – the event/location with respect to which Christmas is 'moving'. Moreover, the semantic function of relative imminence is retained regardless of the tense of the verb phrase, as we can see by placing (31c) in various (complex) past tense forms:

(32) Christmas drew near
(33) Christmas was drawing near

What we see in (32–3) is that the semantic function still relates to relative imminence, regardless of whether the sentence is set in the present or the past with respect to coding time. Now let's consider the situation with respect to occurrence:

(34) a. Christmas has vanished
b. Christmas has disappeared

The example sentences in (34) relate, in contrast, not to relative imminence, but to relative occurrence, and moreover, occurrence that is distant: if the TE is no longer 'visible', its occurrence must be relatively distant from the (implicit) RP. And as with imminence, the reading of occurrence in these sentences is independent of the tense involved:

(35) a. Christmas is vanishing
b. Christmas will vanish

In (35) the sentences still relate to occurrence, regardless of the tense – or modality, as signalled by the modal marker *will* in (35b) – involved. The fact that 'imminence' and 'occurrence' are semantically independent of tense (and futurity, signalled by a modal marker), demonstrates that they are independent of coding time. In contrast, a sentence can involve tense without necessarily involving a t-FoR, in the sense developed in this paper. Let's return to the example of kicking the ball:

(36) John kicked the ball

The event described in (36) is a kicking event. However, the event is not being anchored with respect to anisotropic transience. Rather, the event is being straightforwardly related to coding time: the point at which the utterance is made. Past tense signals that the event occurred prior to coding time. While tense is presumably related, ultimately, to anisotropic transience, tense, as a system, provides a different semantic function from the deictic t-FoR.

7.2 The sequential t-FoR

In this type of t-FoR, the coordinate system is provided by a sequence of events. A given TE is fixed with respect to another event, the RP, with respect to which it is sequenced. A sequence of events is fixed with respect to an O, the first event, or a salient event, in the sequence, from which the RP takes its reference – note that the O can coincide with the RP. Accordingly, the O serves to anchor the RP to the transience type succession, from which the temporal relation earlier/later arises.

As with the deictic t-FoR, the primary way in which English encodes the sequential t-FoR is via ascriptions of motion. However, the motion ascriptions are quite different from deictic t-FoRs. Rather than relating to path-like motion on the sagittal axis they concern expressions involving sequential motion (see Moore 2006). Consider the following examples:

'Earlier'
(37) Christmas comes before New Year's Eve
'Later'
(38) New Year's eve comes after Christmas

In these examples, there are two different TEs, Christmas, in (37), and New Year's Eve in (38). These are the events which are being fixed with respect to the transience type of succession. The RPs, in these examples, are respectively New Year's Eve in (37) and Christmas in (38). In these examples, the RPs are also the Os, the points that anchor the events to the transience type involved here. The consequence of the two events in each example, the TE and the RP/O, being related by virtue of sequential motion (*come before/after*) is the inference that there is a sequential temporal relation holding between the two events such that the TE, Christmas is earlier than the RP/O, New Year's Eve in (37). In contrast, in (38), the TE, New Year's Eve is later than the RP/O, Christmas.

In the sequential t-FoR, the RP and O do not have an egocentric basis, but inhere in the event sequence itself. As such, what makes examples such as (37) and (38) relate to the sequential t-FoR, rather than, for instance the deictic t-FoR, is that the earlier/later temporal relation that emerges does so as it is an inherent feature of the sequence of events, rather than when in time the events are viewed (by an experiencer). Consequently, the reference strategy adopted by this t-FoR is allocentric, as it involves reference between entities, in this case events, which are independent of the egocentric perspective of human experience of now.

One important difference between how language encodes the deictic versus the sequential t-FoRs is the following. In expressions relating to the deictic t-FoR, the TE is determined not by the position occupied by the event in the sentence, but by virtue of being the sole mention of a temporal event. Consider the following examples which relate to the deictic t-FoR:

(39) a. Easter is moving towards us
b. We are moving towards Easter

The TE in each of these examples is that of Easter. However, Easter occupies the subject position in (39a), and oblique (OBL) position in (39b). In contrast, the way English encodes the sequential t-FoR suggests that the TE can only occupy the sentence subject position. This presumably is a consequence of the fact that the sequential t-FoR explicitly encodes two (or more) discrete events.[6] For this reason, there is greater flexibility as to where in the sentence the TE can appear in the deictic t-FoR.

7.3 The extrinsic t-FoR

The extrinsic t-FoR is, arguably, the most complex of the three temporal frames of reference. Extrinsic temporal reference, like other t-FoRs, serves to fix an event in time. This is achieved by virtue of the TE being anchored to the transience type: duration. However, due to reification of this transience type, the temporal relation that arises is an 'encompassing' *temporal matrix*, which fixes an event with respect to the system being used, regardless of one event's relationship with respect to another, or regardless of the individual human experience of time. In this way, the extrinsic t-FoR provides a means of fixing an event in an 'absolute' way, without reference to an observer. A further feature of extrinsic temporal reference is that whatever the system deployed, naturally-occurring periodicities are harnessed. The consequence is that the reference strategy is *periodicity-based*, in contrast to the egocentric and event-based reference strategies of the deictic and sequential t-FoRs.

6 Alan Wallington (p.c.) has pointed out to me that as well as saying that 'Christmas precedes New Year's Eve, one can also say '6.02 am precedes 6.03 am'. While these are not events per se, being clock-based measurements, they may, on occasion, metonymically stand for the events taking place at these times.

There is a broad distinction that can be made in terms of extrinsic temporal reference between *event-reckoning systems* (e.g., calendars), and *time-reckoning systems* (e.g., clocks). While both fix events with respect to the matrix – a reified version of duration – they do so in qualitatively different ways. Both types of system serve to count *periodicities*. That is, they are essentially counting systems, and thereby use the count of periodicities in order to mark when in the temporal matrix an event has occurred (e.g., *The feast occurred in November 1907,* or *The feast started at 11am*), and for how long (e.g., The *feast lasted for two days/hours*). The distinction between the two comes from their relative complexity, which allows time-reckoning systems (clocks) to facilitate counts of smaller units, thereby fixing events with finer precision against the temporal matrix.

In the following I restrict myself to discussion of event-reckoning measurement systems to illustrate the nature of an extrinsic t-FoR. An event-reckoning system provides an extrinsic t-FoR that allows events to be fixed with respect to the system being used. An event-reckoning system has an O which serves as the initial point for setting the system in operation – i.e., the point from which counting begins, thereby anchoring the system to the duration transience type – a RP which serves as the temporal unit which does the fixing, and a TE – the event being fixed against the coordinate system. That is, the extrinsic t-FoR thereby features three coordinates, the hallmark of a FoR. By way of example, in an expression such as *Christmas 1914*, three coordinates are implied: the O (the incarnation of Christ), the RP (the 1,914th year since the incarnation of Christ), and the TE, the event of Christmas that coincides with the 1,914th year since Christ's incarnation).

In order to illustrate the nature of event-reckoning systems, in what follows I will draw on systems prevalent in European and Mesoamerican cultures, as these provide some of the best understood and documented. There are several types of event-reckoning measurement system: I will focus on the two most common of these: the *repeatable* and *open-ended* types. Repeatable event-reckoning systems count units, which are of equal length. This is achieved by making use of (and so counting) naturally-occurring periodicities: a naturally recurring event of a fixed period. Periodicities can be of different kinds, such as the solar cycle – the period required for the Earth to orbit the Sun – the period between vernal and autumnal equinoxes, lunar phases, and so on. However, the most common periodicity used is the day/night cycle.[7]

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7 The day-night cycle is an extremely salient periodicity in human experience. Indeed, its importance is such that humans deploy it in order to determine essential neuro-physical functioning. For instance, the 'master' circadian rhythm, the wake-sleep cycle, is tied very closely to the 24 hour day-night cycle, constituting a hard-wired response to this predictable aspect of our physical environment (see Evans 2004). The phenomenon of jet-lag, for instance, results from a

In a repeatable event-reckoning system, the periodicities that are being counted (e.g., the day/night cycle) are assigned a unique position in the system, often by assigning numerals to the periodicities. Further groupings of periodicities are also common in systems of this kind. For example, in the Gregorian calendar, days are grouped into weeks and months. Once the sequence has been completed, it is repeated, which is what makes such a system one that is repeatable.

To illustrate, consider the main event-reckoning system in Mayan culture (which was developed from earlier Mesoamerican calendar systems). This system was known as the *tzolk'in* calendar, which means 'count of days' (Coe 1992; Gell 1992; Whitrow 1988). In this system, which consists of 260 days, each successive day is numbered 1 to 13, before beginning again at 1. In addition, each day in each 13 day cycle is given a name taken from an inventory of 20 names. As each day across the 13 day cycles has a different name from its corresponding number, this allows 20 cycles of 13 days – hence a total of 260 days. Each day has a unique identifier consisting of a number (from 1–13) and name (from the set of 20). In other words, no day in the 260 day sequence shares both the same number and day name.

The 260 day Mayan calendar is a repeatable event-reckoning system as the 260 day sequence is repeated each time it completes. This system, moreover, does not count years (i.e., cycles of 260 days). A system such as this, for counting days in a finite sequence, provides a means of fixing events that are repeated. This calendar was used by the Maya to determine the time of religious and ceremonial events and divination. As each day is unique it provides a means of fixing a given event, such as particular religious events.

A key feature of repeatable event-reckoning systems is that they require an O: the point which initiates the cycle. This is often derived from a periodicity external to the system (i.e., the days being counted), which thus determines how many units belonging to the system should be counted. In the main Mayan calendar this periodicity is what determined that the system should count 260 days before repeating the sequence.

We don't know for certain what the periodicity was that provided the 260-day Mayan calendar with its O – day 1 of a sequence of 260 – as the 260 day cycle appears not to be based on any geophysical or astronomical periodicity. That said, there are a number of plausible theories. One relates to the observation that the human gestation period is around 260 days – the average number of days from the first day of the first missed menstrual period until birth (Miller and Taube

discrepancy between the wake-sleep cycle and day-night cycle, due to sudden removal from the location to which an individual's wake-sleep cycle is entrained.

1993; Tedlock 1982).[8] Another relates to the period from sowing of crops until harvest, which is roughly 260 days (Malmström 1973). Whatever the precise motivation, the external periodicity determined an initial point for the count – the origo – and as a consequence, a final point, giving rise to the 260 day sequence before reverting to the O.

Other repeatable event-reckoning systems take their O from other periodicities. Clear examples of this are those that set their O with respect to the solar cycle. The Gregorian calendar is also, essentially, a repeatable event-reckoning system, which uses the solar cycle to set its O. The Gregorian calendar consists of 365 days, and 366 days every fourth year of the sequence. The reason for an extra day every fourth iteration is that the day-night cycle and the solar cycle do not align precisely. In fact, in the Gregorian calendar, which modified the earlier Julian calendar by papal bull in 1582, a sequence actually consists of 365.2425 days – the Gregorian calendar is thus a specific sub-type of repeatable event-reckoning systems, an *arithmetic repeatable event-reckoning system,* using the solar cycle to determine an 'arithmetic' and hence notional day/night unit.[9]

It is worth noting, however, that the O can in principle be set at any point in the repeatable event-reckoning system: it is not necessary that it is set as the initial point, i.e., day number one. For instance, in parts of mediaeval Europe, the official New Year began on March 25th, which was Lady Day, believed to be the date when Mary was informed by an angel that she was carrying the unborn Jesus. Venice adopted January 1st as the first day of the year in 1522. England didn't follow suit until 1752.

The second type of event-reckoning system I discuss is the open-ended type. This provides an unambiguous means of fixing events with respect to a unique O that is internal to the system, rather than external to it, as in the case of repeatable event-reckoning systems. An example is the Anno Domini dating system developed in AD 525. This system took as its O the presumed incarnation of Christ. It is an open-ended as opposed to repeatable event-reckoning system as its O is a unique event that occurs at only one point in the system. This thereby provides

8 This calculation of the gestation period differs from Naegele's Rule, which assumes that gestation is the period between the first day of the last menstrual period and birth, which is circa 280 days (or 40 weeks).

9 One obvious advantage of using the solar cycle to set the O of a repeatable event-reckoning sequence is that it provides a ready means of fixing events in the agrarian cycle. After all, the solar cycle determines seasonal variation, and hence is the cycle most important for agriculture. Mayan society thus employed two calendars, a 260 sequence for religious events, and a 365 day system, set with respect to the solar cycle, for fixing agricultural events such as planting and harvesting.

the system with an anchor to the transience type: duration. Dating systems such as this work by providing each temporal unit – such as a day – with a unique reference, by virtue of its relationship with the O. This then allows the identification of an event by virtue of the day – or grouping of days, e.g., month or year – in which it occurs. Moreover, events can be fixed either side of the O: counting can proceed 'forwards', i.e., later than the O, or 'backwards', i.e., earlier than the O.

In practice, calendar and dating systems often – although not always – work in conjunction with one another. For instance, the Gregorian calendar adopts the Anno Domini dating system in order to identify distinct iterations of 365 (or 366) day sequences, while in Mayan culture, the 260 day calendar was used in conjunction with what was known as the Long Count dating system in order to precisely fix events over longer periods.

One difference between the two types of event-reckoning systems considered concerns the temporal relation captured. Repeatable event-reckoning facilitates the fixing of event iteration. This allows the identification of what might be referred to as *cyclical time*.

In contrast, open-ended (or dating) event-reckoning systems relate to what we can informally refer to as *linear time*. Evidence for this distinction comes from language. Consider the example below:

'Linear time'
(40) Christmas 1914 saw a football match between British and German forces

In this example, a specific event is being identified: a unique Christmas event. It is identifiable precisely because it is the 1,914th iteration, taking as reference point a particular temporal unit, the 1,914th year since the incarnation of Christ – the traditional incarnation of Christ is assumed to be AD1 in the Anno Domini system, there being no year zero. Hence, the TE – the 1,914th iteration of Christmas – occurs in the year 1914, the (RP) – following the presumed birth of Christ (O), which anchors the system to the transience type duration.

Now consider the example in (41):

'Cyclical time'
(41) Christmas has come round again

In this example, the event being fixed is being done so not as a specific instance of this type, but in terms of when in a sequence Christmas as a type of event occurs. This is possible because Christmas is fixed with respect to a sequence of days that is repeatable: in this case, as determined by the Gregorian calendar, providing a sequence of 365 (or 366) days. Hence, Christmas as an event type is fixed by virtue of a repeatable event-reckoning system – a calendar. This then contrasts with linear time, where each instance of Christmas is fixed by virtue of an open-ended event-reckoning system – a dating system – which relates the time unit that coincides with the instance, to an O.

In the example in (41), the TE Christmas is fixed with respect to an RP, which is the position occupied by Christmas in the repeatable sequence. The lexicalisation of this in terms of curvilinear motion *come round* is consistent with the repeatable nature of this type of event-reckoning. After all, curvilinear motion gives rise, in principle, to revisiting an earlier location, and hence repetition.

8 Summary

This paper has proposed a theoretical account of temporal frames of reference (t-FoRs). My starting point has been that current perspectives, while insightful, have not fully incorporated the inalienable nature of temporal reference into their accounts: relating to the phenomenon of transience. I began by considering the nature of temporal representation. I argued that our representation for time is constituted, at least in part, of directly perceived temporal experience which is, in principle, distinct from sensory-motor experience. Further arguments were then considered for distinguishing between space and time. For instance, the domains were compared and contrasted along the parameters of magnitude, dimensionality and directedness. It was concluded that each of these parameters, as they relate to the domain of time, give rise to the experience of transience. Transience appears to be a property associated with time and not space. Moreover, temporal reference relates to transience: events are fixed with respect to transience. And given that temporal reference relates directly to transience, a property absent in the domain of space, it follows that spatial and temporal reference are both distinct and distinguishable, notwithstanding the use of spatial representations in structuring t-FoRs. I then examined the nature of t-FoRs, considering the various elements that constitute a t-FoR, including a target event (TE) – the event being fixed with respect to transience – the reference point (RP) – the temporal unit (or event) which locates the TE – and the origo (O) – which anchors the TE to the type of transience associated with a given t-FoR. It was concluded that different types of transience give rise to distinct types of temporal relations, the hallmark of a distinct t-FoR. Three temporal relations were identified: a future/past relation, an earlier/later relation and the matrix relation. These relations give rise to distinct t-FoRs: the deictic, sequential and extrinsic, which were briefly introduced.

References

Abraham, Anna, Ricarda Ines Schubotz & D. Yves Cramon. 2008. Thinking about the future versus the past in personal and non-personal contexts. *Brain Research* 1233, 106–119.

Addis, Donna Rose, Alana T. Wong & Daniel L. Schacter. 2007. Remembering the past and imagining the future: Common and distinct neural substrates during event construction and elaboration. *Neuropsychologia* 45, 1363–1377.

Baddeley, Alan. 1966. Time estimation at reduced body temperature. *American Journal of Psychology* 79(3), 475–9.

Bender, Andrea, Sieghard Beller & Giovanni Bennardo. 2010. Temporal frames of reference: Conceptual analysis and empirical evidence from German, English, Mandarin Chinese, and Tongan. *Journal of Cognition and Culture* 10, 283–307.

Bender Andrea, Annelie Rothe-Wulf, Lisa Hüther & Sieghard Beller. 2012. Moving forward in space and time: How strong is the conceptual link between spatial and temporal frames of reference FoRs? *Frontiers in Psychology* 3(486), 1–11.

Boroditsky, Lera. 2000. Metaphoric structuring: Understanding time through spatial metaphors. *Cognition* 75(1), 1–28.

Boroditsky, Lera & Michael Ramscar. 2002. The roles of body and mind in abstract thought. *Psychological Science* 13(2), 185–188.

Botzung Anne, Ekaterina Denkova, Philippe Ciuciu, Christian Scheiber, Lilianne Manning. 2008. The neural bases of the constructive nature of autobiographical memories studied with a self-paced fMRI design. *Memory* 16, 351–363.

Buhusi, Catalin. V. & Warren H. Meck. 2005. What makes us tick? Functional and neural mechanisms of interval timing. *National Review of Neuroscience* 6, 755–765.

Casasanto, Daniel & Lera Boroditsky. 2008. Time in the mind: Using space to think about time. *Cognition* 106, 579–93.

Chafe,Wallace. 1994. *Discourse, Consciousness, and Time: The Flow and Displacement of Conscious Experience in Speaking and Writing*. Chicago: University of Chicago Press.

Clark, Herbert. 1973. Space, time, semantics, and the child. In T. Moore (ed.), *Cognitive Development and the Acquisition of Language*, 27–63. New York: Academic Press.

Coe, Michael. 1992. *Breaking the Maya Code*. New York: Thames and Hudson.

Coveney, Peter & Roger Highfield. 1991. *The Arrow of Time: The Quest to Solve Science's Greatest Mystery*. London: Flamingo.

Davies, Paul. 1996. *About Time: Einstein's Unfinished Revolution*. London: Penguin.

Droit-Volet, Sylvie & Warren H. Meck. 2007. How emotions colour our perception of time. *Trends in Cognitive Science* 11, 504–513.

Duffy, Sarah. E & Michele. I. Feist. To appear. Individual differences in the interpretation of ambiguous statements about time. *Cognitive Linguistics*.

Eddington, Arthur. 1928. *The Nature of the Physical World*. London: Macmillan.

Einstein, Albert. [1916] 2005. Relativity: The special and general theory R. W. Lawson, Translation. New York: Pi Press. Original work published 1916.

Evans, Vyvyan. 2004. *The Structure of Time: Language, Meaning and Temporal Cognition*. Amsterdam: John Benjamins.

Evans, Vyvyan. 2009. *How Words Mean: Lexical Concepts, Cognitive Models and Meaning Construction*. Oxford: Oxford University Press.

Evans, Vyvyan. In press. *Language and Time: A Cognitive Linguistics Approach*. Cambridge: Cambridge University Press.

Fauconnier Gilles & Mark Turner. 2008. Rethinking metaphor. In R. Gibbs (ed.), *Cambridge Handbook of Metaphor and Thought*, 53–66. Cambridge: Cambridge University Press.
Flaherty, Michael. 1999. *A Watched Pot: How We Experience Time*. New York: New York University Press.
Fraisse, Paul. 1963. *The Psychology of Time*. New York: Harper and Row.
Fraisse, Paul. 1984. Perception and estimation of time. *Annual Review of Psychology* 35, 1–36.
Galton, Anthony. 2011. Time flies but space doesn't: Limits to the spatialization of time. *Journal of Pragmatics* 43, 695–703.
Gell, Alfred. 1992. *The Anthropology of Time*: *Cultural Constructions of Temporal Maps and Images*. Oxford: Berg.
Gentner, Dedre, Mutsumi Imai & Lera Boroditsky. 2002. As time goes by: Evidence for two systems in processing space time metaphors. *Language and Cognitive Processes* 17(5), 537–65.
Gilbert, Daniel T. & Timothy D. Wilson. 2007. Prospection: Experiencing the future. *Science* 317, 1351–1354.
Grady, Joseph. 1997. *Foundations of Meaning: Primary metaphors and Primary Scenes*. Doctoral dissertation, University of California, Berkeley.
Harrington, Deborah L., Kathleen Y. Haaland & Robert T. Knight. 1998. Cortical networks underlying mechanisms of time perception. *Journal of Neuroscience* 18(3), 1085–95.
Hassabis, Demis, Dharshan Kumaran, Seralynne D. Vann & Eleanor A. Maguire. 2007. Patients with hippocampal amnesia cannot imagine new experiences. *PNAS* 104(5), 1726–1731.
Hoagland, Hudson. l933. The physiologic control of judgments of duration: Evidence for a chemical clock. *Journal of General Psychology* 9, 267–287.
Ingvar, David H. 1985. "Memory of the future": An essay on the temporal organization of conscious awareness. *Human Neurobiology* 4(3), 127–136.
Ivry, Richard & Rebecca Spencer. 2004. The neural representation of time. *Current Opinion in Neurobiology* 14(2), 225–232.
Kemmerer, David. 2005. The spatial and temporal meanings of English prepositions can be independently impaired. *Neuropsychologia* 43, 797–806.
Kranjec, Alexander. 2006. Extending spatial frames of reference to temporal concepts. *Proceedings of the 28th Annual Conference of the Cognitive Science Society*, 447–452.
Kranjec, Alexander & Anjan Chatterjee. 2010. Are temporal concepts embodied? A challenge for cognitive neuroscience. *Frontiers in Psychology* 1, 240.
Kranjec, Alexander, Eileen Cardillo, Gwenda L. Schmidt, Matthew Lehet & Anjan Chatterjee. 2012. Deconstructing Events: The Neural Bases for Space, Time, and Causality. *Journal of Cognitive Neuroscience* 24(1), 1–16.
Lakoff, George. 1993. The contemporary theory of metaphor. In A. Ortony (ed.), *Metaphor and Thought*. 2nd edition. 202–251. Cambridge: Cambridge University Press.
Lakoff, George & Mark Johnson. 1980. *Metaphors We Live By*. Chicago: University of Chicago Press.
Lakoff, George & Mark Johnson. 1999. *Philosophy in the Flesh*. New York: Basic Books.
Le Poidevin, Robin. 2003. *Travels in Four Dimensions: The Enigmas of Space and Time*. Oxford: Oxford University Press.
Levinson, Stephen. 2003. *Space in Language and Cognition: Explorations in Linguistic Diversity*. Cambridge: Cambridge University Press.
Malmström, Vincent H. 1973. Origin of the Mesoamerican 260–day calendar. *Science* 181(4103), 939–941.

Mauk, Michael & Dean Buonomano. 2004. The neural basis of temporal processing. *The Annual Review of Neuroscience* 27, 307–40.
McGlone, Matthew & Jennifer L. Harding. 1998. Back or forward? to the future: The role of perspective in temporal language comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 24(5), 1211–1223.
Miller, Mary & Karl Taube. 1993. *An Illustrated Dictionary of the Gods and Symbols of Ancient Mexico and the Maya*. London: Thames and Hudson.
Moore, Kevin E. 2000. *Spatial Experience and Temporal Metaphors in Wolof: Point of View, Conceptual Mapping, and Linguistic Practice*. Doctoral dissertation, University of California, Berkeley.
Moore, Kevin E. 2006. Space-to-time mappings and temporal concepts. *Cognitive Linguistics*, 17(2), 199–244.
Moore, Kevin E. 2011. Ego-perspective and field-based frames of reference: Temporal meanings of FRONT in Japanese, Wolof, and Aymara. *Journal of Pragmatics* 43, 759–776.
Nelson, Katherine. 1996. *Language in Cognitive Development: The Emergence of the Mediated Mind*. Cambridge: Cambridge University Press.
Noulhiane, Marion, Nathalie Mella, S. Samson, R. Ragot & Viviane Pouthas. 2007. How emotional auditory stimuli modulate time perception. *Emotion* 7, 697–704.
Núñez, Rafael & Eve Sweetser. 2006. With the future behind them: Convergent evidence from Aymara language and gesture in the crosslinguistic comparison of spatial construals of time. *Cognitive Science* 30, 401–450.
Okuda, Jiro, Jiro Okuda, Toshikatsu Fujii, Hiroya Ohtake, Takashi Tsukiura, Kazuyo Tanji, Kyoko Suzuki, Ryuta Kawashima, Hiroshi Fukuda, Masatoshi Itoh, Atsushi Yamadori. 2003. Thinking of the future and past: The roles of the frontal pole and the medial temporal lobes. *NeuroImage* 19, 1369–1380.
Ornstein, Robert. [1969] 1997. *On the Experience of Time*. Boulder: Westview Press.
Pöppel, Ernst. 1978. Time Perception. In R. Held, H. W. Leibowitz & H.-L. Teuber (eds.), *Handbook of Sensory Physiology*, 713–29. Heidelberg: Springer.
Pöppel, Ernst. 2004. Lost in time: a historical frame, elementary processing units and the 3 second window. *Acta Neurobiologiae Experimentalis Wars* 64, 295–301.
Pöppel, Ernst. 2009. Pre-semantically defined temporal windows for cognitive processing. Philosophical Transactions of the Royal Society B 364, 1887–1896.
Pouthas, Viviane & Séverine Perbal. 2004. Time perception does not only depend on accurate clock mechanisms but also on unimpaired attention and memory processes. *Acta Neurobiologiae Experimentalis* 64, 367–385.
Rammsayer, Thomas. H. 1997. On the relationship between personality and time estimation. *Personal Individual Differences* 23, 739–744.
Rubia Katya, Rozmin Halari, Anastasia Christakou & Eric Taylor. 2009. Impulsiveness as a timing disturbance: Neurocognitive abnormalities in attention-deficit hyperactivity disorder during temporal processes and normalization with methylphenidate. *Philosophical Transactions of the Royal Society B: Biological Sciences* 364, 1919–1931.
Sakai, Katsuyuki, Narender Ramnani & Richard E. Passingham. 2002. Learning of sequences of finger movements and timing: Frontal lobe and action-oriented representation. *Journal of Neurophysiology* 88, 2035–2046.
Schacter, Daniel L. & Donna R. Addis. 2007. The cognitive neuroscience of constructive memory: Remembering the past and imagining the future. *Philosophical Transactions of the Royal Society B: Biological Sciences* 362, 773–786.

Schacter, Daniel L., Kenneth A. Norman & Wilma Koutstaal. 1998. The cognitive neuroscience of constructive memory. *Annual Review of Psychology* 49, 289–318.
Schacter, Daniel L., Donna R. Addis & Randy L. Buckner. 2007. The prospective brain: Remembering the past to imagine the future. *Nature Reviews Neuroscience* 8, 657–661.
Schubotz, Ricarda I. & D. Yves von Cramon. 2001. Interval and ordinal properties of sequences are associated with distinct premotor areas. *Cerebral Cortex* 11, 210–222.
Shinohara, Kazuko & Yoshihiro. Matsunaka. 2010. Frames of reference, effects of motion, and lexical meanings of Japanese FRONT/BACK terms. In V. Evans & P. Chilton (eds.), *Language, Cognition and Space: The State of the Art and New Directions*, 293–315. London: Equinox.
Sinha, Chris, Vera da Silva Sinha, Jörg Zinken & Wany Sampaio. 2011. When time is not space: The social and linguistic construction of time intervals in an Amazonian culture. *Language and Cognition* 3(1), 137–169.
Smart, John Jamieson Carswell. 1949. The River of Time. *Mind* 58(232), 483–494.
Szpunar, Karl K., Jason M. Watson & Kathleen B. McDermott. 2007. Neural substrates of envisioning the future. *PNAS* 104, 642–647.
Talmy, L. 2000. *Toward a Cognitive Semantics Volume I: Concept Structuring Systems*. Cambridge: MIT Press.
Tedlock, Barbara. 1982. *Time and the Highland Maya*. Albuquerque: University of New Mexico Press.
Tenbrink, Thora. 2007. *Space, Time, and the Use of Language: An Investigation of Relationships*. Berlin: Mouton de Gruyter.
Tenbrink, Thora. 2011. Reference frames of space and time in language. *Journal of Pragmatics* 43, 704–722.
Traugott, Elizabeth. C. 1978. On the expression of spatio-temporal relations in language. In J. Greenberg (ed.), *Universals of Human Language*, 369–400. Stanford: Stanford University Press.
Tulving, Endel. 1983. *Elements of Episodic Memory*. Oxford: Oxford University Press.
Tulving, Endel. 1985. How many memory systems are there? *American Psychologist* 40, 385–398.
Turetzky, Philip. 1998. *Time*. London: Routledge.
Turner, Frederick & Ernst Pöppel. 1983. The neural lyre: Poetic meter, the brain and time. *Poetry* 142(5), 277–309.
Varela, Francisco. 1999. Present-time consciousness. *Journal of Consciousness Studies* 6(2/3), 111–140.
Wallington, Alan. 2012. Back to the future: Just where are forthcoming events located? In Filipovic, L. & K. Jaszczolt (eds.), *Space and time across languages and Cultures Vol. II: Language, culture and cognition*, 83–99. Amsterdam: John Benjamins.
Wearden, John & Ian Penton-Voak. 1995. Feeling the heat: Body temperature and the rate of subjective time, revisited. *Quarterly Journal of Experimental Psychology* 48B, 129–41.
Whitrow, Gerald James. 1988. *Time in History*. Oxford: Oxford University Press.
Wiener, Martin, Peter Turkeltaub & H.B. Coslett, H. Branch. 2010. The image of time: A voxel-wise meta-analysis. *Neuroimage* 49, 1728–1740.
Wittmann, Marc. 2009. The inner experience of time. *Philosophical Transactions of the Royal Society B* 364, 1955–1967.
Wittmann, Marc & Ernst Pöppel. 2000. Temporal mechanisms of the brain as fundamentals of communication – with special reference to music perception and performance. *Musicae Scientiae* 1999–2000 Special Issue, 13–28.

Wittmann, Marc, Tanja Vollmer, Claudia Schweiger & Wolfgang Hiddemann. 2006. The relation between the experience of time and psychological distress in patients with haematological malignancies. *Palliative Supportive Care* 4, 357–363.
Zakay, Dan & Richard Block. 1997. Temporal cognition. *Current Directions in Psychological Science* 6, 12–16.
Zakay, Dan & Richard Block. 2004. Prospective and retrospective duration judgments: An executive-control process. *Acta Neurobiologiae Experimentalis* 64, 319–328.
Zinken, Jörg. 2010. Temporal frames of reference. In V. Evans & P. Chilton (eds.), *Language, Cognition and Space: The State of the Art and New Directions*, 479–498. London: Equinox Publishing.