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Temporal Subitizing and Temporal Counting: a Proposal between Vision and Action

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Abstract. How is our temporal experience possible? When we hear a song, we are aware that every note is before and after another note (and that's how we remember it), but we also 'experience-as-present' more than one note at a time. To answer this question, I suggest an analogy with the difference drawn, in the spatial case, between the two different mechanisms of counting and 'subitizing' (the immediate visual capture of a certain number of items as a single object). My proposal is to identify two different mechanisms even in the temporal case: a temporal counting, a coconscious experiential 'single look' of a temporal interval; and a temporal subitizing, an atomic storing operation which organizes every event in a mathematical, point-like sequence. These two mechanisms are taken to be operative always and together; we never cease to store the events encountered in a temporal line, but we also experience a subgroup of them as present.

Keywords. Models of Temporal Understanding, Phenomenal Temporality, Specious Present.

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1 The models of our temporal phenomenology and a shared problem

The three main accounts[1] of our experience of time and presentness are the Cinematic Model, the Retentional Model and the Extentional Model. Cinematists reject the idea of a Specious Present. They maintain that our temporal phenomenology is a succession of momentary states of consciousness. In our phenomenology we always know what comes first and what second; then, the best model to describe our temporal awareness is one in which there are momentary states of consciousness (physiologically momentary: about 30ms, time under which we can't distinguish the order of two stimuli[2]). But how can they account for perceptions of motions? While, in fact, there is a distinct frame to point at when we want to know where does the experience "I see the green apple on the desk" come from (there is a frame containing the green apple), we can't do the same with the also very familiar experience "I see the green apple falling from the desk" (in every frame the apple is in one position: it is never falling). If our perceptual consciousness consists of a succession of momentary experiences, we never really perceive the apple falling in the same way we perceive it 'being green'. Where, then, does this dynamical feature of our experience come from? It seems that a story needs to be told about how, from this succession of experiences, we have an experience of succession. One thing is to have in mind the different positions that an object occupied in time and have the cognitive understanding that it moved, and another thing is to directly perceive it moving[3].

It is to save this last intuition that the two other models of temporal experience were born – Retentionalism and Extentionalism. These models are realists about phenomenal temporality: change, succession and persistence can be directly perceived or apprehended[4]. Both Extensional and Retentional theorists agree that a temporal spread of contents can be apprehended as a unity. Not only, then, simultaneous contents can be experienced together, but even contents that are successive; contents which are apprehended as unified in this way belong to a single specious present. How is it possible, however, to perceive an extended present? When we hear three close auditory tones, we seem to hear the musical phrase as present, and yet we also hear the notes as successive, and

[1] See Rashbrook (2013), Prosser (2013, 2016), and Hoerl (2014b,a, 2015) for an extensive discussion on the matter.

[2] Stimuli of around 1ms need to be separated from one another by in interval of around 30 msec if they are to be perceivedasa succession – a result which holds across sensory modalities. Stimuli which are separated by shorter intervals are not perceived as distinct.

[3] Obviously enough, many refined arguments could be put forward by the Cinematist to defend her position: all I'm trying to do here, however, is to present the main models of our temporal phenomenology to show how the Specious Present is present in them.

[4] There is the possibility to build a 'Cinematist Realist' model, but virtually every philosopher of time who defends Cinematism is an Anti-realist about phenomenal temporality.

therefore as extending over an interval. How could a succession of elements – elements which are experienced as *before* and *after* – also be experienced as present *in toto*? Retentionalist and Extentionalist, while accepting both the idea of an extended Specious Present, give different accounts of this apparent paradox.

Retentionalists agree that our experiences occur within episodes of consciousness which lack an objective, clock-time extension: but these episodes, they maintain, are composed by an immediate experience *and* a representation (or retention) of the recent past; the result is that the contents of these experiences represent temporally extended intervals. The stream of consciousness, then, is composed of succession of momentary states – just as the Cinematists claim: the difference, however, is that the experience of these momentary states is one of duration. The confinement to a momentary present is seen by Retentionalists as a condition for contents to be experienced together: phenomenal unity needs the simultaneous presentation of contents to a single momentary awareness. Retentionalists, however, are typically accused to have invented "nothing but a new word" (Dainton 2000, p. 155): what is a retention, and in what differs from a memory? Until we explain how does it work, it is just an *ad hoc* solution. How is that possible that a portion of what the Retentionalist herself calls recent 'past' is added to our present, point-like experience, creating a new whole? Shouldn't there be some sort of difference between the present and the retained past? Isn't it, then, just another version of the Cinematic model, in which we simply call the awareness of the recent past with a different name? If we choose the other horn of the dilemma, however – clearly differentiating memories and retentions – we risk to multiply the experiences: shouldn't we hear-as-present a sound in all the different point-like Specious Presents that contain it? This is why Extentionalists claim that the Specious Present is not merely experiential, but extends over clock-time; they hold that the atomic unit of our perception is an extended period of time: we have an experience of succession because we directly experience the succession. The Retentionalist doctrine that diachronic phenomenal unity can only exist in strictly momentary states of consciousness is rejected, in favour of a more 'natural' model of temporal awareness: change and persistence are incorporated in our experience in a quite straightforward way, since our stream of consciousness is composed of a succession of an extended chunk of experience; the main Extentionalist claim, then, is that experience itself is extendend, and not just its content (vehicle and content share their temporal properties). The Extentionalists' Specious Present is itself temporally extended, and its parts succeed one another in time in just the way they seem to: our experiences extend over a period of real time, in a way which (almost infallibly) matches the phenomenal period it presents.

Realists about phenomenal temporality, such as Extentionalists and Reten-

tionalists, explain the immediacy associated with experiences of change, persistence, succession, in a quite direct way; their problem however, one that Cinematists don't seem to face, is to explain how is it possible that the succession experienced in the extended present doesn't collapse in a temporal *unicum*: how is it possible, for contents that are all experienced as present, to be presented to our conscious life as in succession rather than simultaneously? How come that not only *objectively*, but even *phenomenologically*, there is a before and an after in a Specious Present? Shouldn't the extended present be experienced as a totul-simul (we directly experience the succession of notes without confusing their order)?

How, moreover, should we divide one extended present from another? While it was obvious in the Cinematist case (every single perception, such as a note, is one present experience), it is not so obvious in the Retentionalist or Extentionalist case: how long are these extended present experiences, and how they succeed one another without giving the feeling of a continuous hiccup (which is a stream, of course, but a very unappealing one)? There is a double dilemma, then, for the realist about phenomenal temporality: how could it be that within these wholes there is a succession, a before and an after? And how could it be that each experienced whole seamlessly gives way to the next?

In this paper I sketch a possible way out from this double dilemma; what the three different models of our temporal phenomenology have in common is that they all try to reduce one side of our temporal phenomenology to the other; Cinematists give priority to the phenomenology of succession, and try to minimize the experience of a Specious Present; Extentionalists and Retentionalists give priority to the Specious Present, but they have problems when it comes to explain why our extended experiences of a temporal 'present' don't merge all the perceptions in one simultaneous datum. The novelty of my proposal consists in the acceptance of the paradox – cognitive neuroscience may indicate us the way to a better model, and our possibility to act and react will be crucial in this phenomenological model of our temporal perception.

2 Synchronic and diachronic unity

There are two macro-areas of concern regarding the phenomenology of our temporal experience: questions about synchronic unity at a time, and questions about diachronic unity over time. Not only, in fact, do we experience many successive movements of an object in front of us as fluidly reunited in a temporal extended now, our present moment; we also experience an endless stream of these 'nows', without being capable of pinpointing, locating or even remotely feeling any kind of definite boundary between them. There have been attempts to argue in favor of a unified account, providing one answer to both questions: how-

ever, it seems that there are some structural differences that make it impossible. Oliver Rashbrook (2013) argues very convincingly that similar solutions hide two very different notions of 'togetherness'. While in fact, on the one hand, 'being experienced together' is a transitive relation in our experience of synchronic unity at a time, it is a non-transitive relation in our experience of diachronic unity over time (the continuity of consciousness tells a very different story from that of a single, prolonged experience during our waking hours). But the relation can't be both, at least not in a *unified* account of our temporal phenomenology.

There seems to be a genuine problem here. Consider the auditory experience of a fast piano song; our phenomenological experience of 'the present' is a single look, so to speak, to a brief succession of notes. We simply *can't* experience-as-present only one note at a time (remember: it is a *fast* song). Still, after one minute not only are we *aware* that we are not experiencing the beginning of the song: we also don't experience-as-present the first notes of the song. There must be in play here two very different ways to have a temporal experience: on the one hand, there is a brief but extended present, that even if distinguishes the succession of (say) three notes, comprises them all in a single temporal present experience – as the single vision of three dots on a screen: you can tell that there is one on the left, one in the center, and one on the right: still, you don't need to look singularly in turn at every one of them to tell. In this case, 'togetherness' is a transitive relation. On the other hand, there is a completely different way to temporally experience the song: instead of a single look, it resembles much more the operation of storing the notes in succession; in this case, 'togetherness' has a whole different meaning.

It seems that there are two different phenomenological processes going on: if we had absolute pitch and a prodigious, Mozart-like memory, at the end of the song we would remember perfectly the stream of the notes, being capable of saying which were played before, and which were played after; if we chose a random note, we would be able to tell which notes were in its past, and which notes were in its future; our total temporal experience of the song, then, is that of a continuous stream of temporally ordered single notes; a mathematical succession of points, so to speak. A totally different process, however, is responsible for our direct temporal experience while the song is being played. Think of what you would answer if someone asked you, during the song, "what are you hearing now?": instead of an ordered succession of single notes being present and successively, in turn, being stored in the past, your present experience would much more likely be that of a brief succession of multiple notes, which – even if they are in succession – are all felt as part of the same present; there are more-than-one notes in our experiential now.

Let me make another example. Suppose you live in a poor and dangerous neighborhood; one night, you got frightened by the sudden sound of two close

gun shots (say, 100ms from one another). Try to imagine your temporal experience: even if you heard two separate shots, you do not experience the first 'as past' when you hear the second. Nonetheless, when the police officers interrogate you, you have no problem telling that one shot was *before* the other; you are absolutely aware that, technically, when one was present the other was in its past. Indeed, at the end of that ugly night, you remember a stream, a sequence of temporal ordered gun shots; the single experience that you had when you heard the two close shots – when you could actually act – is lost, replaced by an ordinate succession available for your memory.

Maybe the simplest option is even the right one: if we experience two such different things, it could be because there are two different phenomenological processes going on, and our temporal experience is twofold: to make my proposal clearer, I am going to propose an analogy with a spatial debate, which has significantly been tackled with the recourse of such a dualism between two distinct ways of operating of our intellect: counting and 'subitizing'. It is important to stress at this point, however, that the analogy serves merely to indicate the direction I am taking: I do not intend to claim that there is a straightforward relation between my temporal model and the spatial models that make use of the notion of 'subitizing'; it is obviously possible to explore the conceptual link between them, but it is beyond the purposes of the present paper.

'Subitizing' is a latinism coined[5] in the mid-fifties to describe the immediate visual capture of a certain number of items, to be distinguished from the usual action of counting. The idea behind it was to see if there were a cognitive description of our everyday-life different performances in front of streams of not-grouped and grouped numbers (4939724 and 4,939,724; car plates; bank accounts; etc.). Experimental results[6] showed a significant difference between judgments made for displays composed of one to four items, and for displays of more items; of course, response times always rise with the increase of the number of the items showed, but it is often claimed that there is a dramatic difference between the two groups[7] (see Figure 1).

[5] See Kaufman et al. (1949).

[6] See for example Trick and Pylyshyn (1994), or Camos and Tillmann (2008).

[7] Inside the range 1–4 objects, there is an increase of the time necessary for an accurate response of about 50ms every added element; in the range +4 objects, however, the increase in response time becomes of about 300ms.

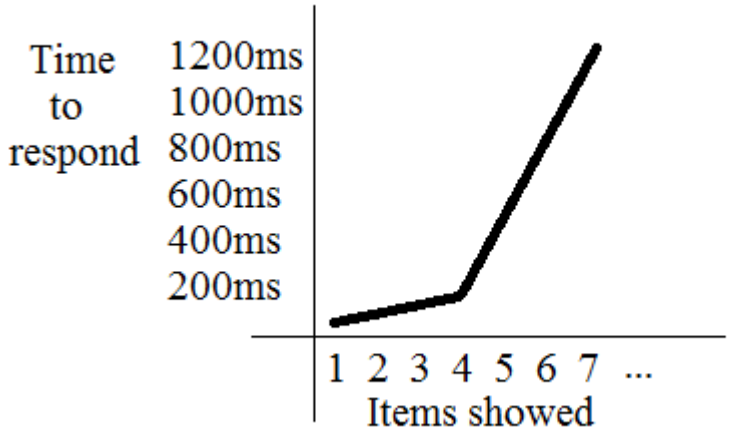

Figure 1[8]

In current scientific literature we find a lot of different models to explain these results. Sometimes (rarely) the limit between subitizing and counting is set after the third object, instead of the fourth; given that there is never an indisputable discontinuity in the curves of response, moreover, there are even those who deny that there are two different mechanisms to determine visual numerosity. Gallistel and Gelman (1991), for example, famously claimed that even small sets of items are quantified by serial counting, albeit with faster speed than for larger sets: subitizing, then, would just be a fancy word to say 'fast counting'. Others see in our ability to subitize small groups of numbers a similarity to object recognition: Mandler and Shebo (1982), for example, argued that subjects recognize the characteristic geometric configuration of sets of objects (for example: 1, point; 2, line; 3, triangle). This pattern recognition would fail for sets of more items, at which point the subject would then start to (slowly) count. Trick and Pylyshyn (1994) attributed subitizing to the parallel assignation of pointers called 'fingers of instantiation' to each object in a visual display; these 'fingers', it is assumed, are available in a limited number (four), as it is suggested by multiple object tracking experiments. Subitizing, then, would be based primarily on preattentive processing, and be dissociated from serial counting. To similar conclusion came Dehaene and Cohen (1994), Simon and Vaishnavi (1996), Robertson et al. (1997), Piazza et al. (2002), Maloney et al. (2010).

A disquisition on the single models' merit exceeds the purposes of this thesis; it is sufficient to say that, even if many possible explanations have been put for-

[8]I created this figure on the basis of the data presented in Akin and Chase (1978), Klahr and Wallace (1976) and Mandler and Shebo (1982); in their result, it is shown the non-trivial fact that the subjects of the experiments needed, in order to press a button and tell the exact number of elements on a screen, 25 to 100 more milliseconds every added element in the range 1-4, but after the fourth element the difference for every added element suddenly raised to 250-350 milliseconds per added element. The 'elbow' shown in the figure is also confirmed by Trick and Pylyshyn (1994), in which it is considered the percentage of errors made by the subjects.

ward to explain such a dramatic difference between our abilities to enumerate objects, there seems to be a convincing amount of proofs pointing in the direction of the existence of two different mechanisms at the basis of our different performances in front of a visual display of objects. What I'm proposing, without suggesting a straightforward relation, is a temporal analogy. It seems, in fact, that even in the temporal case there are at work two different processes: while a *temporal subitizing* has an 'action guidance task', which is responsible for our directly experienced present – a single 'temporal look' at an extended period of time that comprises a succession of more notes (for example) in an immediate co-conscious present temporal experience – a *temporal counting* has the cognitive task to store in succession the events perceived. Before turning to the main argument of this paper, however, it is necessary to draw a distinction between long-term, short-term and working memory.

3 Long-term, Short-term and Working memory

Three types of memory are distinguished in scientific literature: long-term memory, short-term memory, and working memory. It is crucial to introduce this distinction at this point of the paper because, as I will argue in the next session, it is possible that temporal subitizing has to do with short-term or working memory mechanisms, while temporal counting has to do with long-term memory processes. Let me proceed in order and clarify the distinctions, first.

Long-term memory is a vast store of knowledge and a record of prior events, and it exists according to all theoretical views. Short-term memory reflect faculties of the human mind that can hold a limited amount of information in a very accessible state temporarily. One might relate short-term memory to a pattern of neural firing that represents a particular idea and one might consider the idea to be in short-term memory only when the firing pattern, or cell assembly, is active. The individual might or might not be aware of the idea during that period of activation. As Nelson Cowan (2001, 2008) showed, short-term memory differs from long-term memory in respect to temporal decay and (crucial for the present argument) chunk capacity limits. Working memory, then, has been conceived and defined in three different, slightly discrepant ways: as short-term memory applied to cognitive tasks, as a multi-component system that holds and manipulates information in short-term memory, and as the use of attention to manage short-term memory. Regardless of the definition, there are some measures of memory in the short term that seem routine and do not correlate well with cognitive aptitudes and other measures (those usually identified with the term "working memory") that seem more attention demanding and do correlate well with these aptitudes. What is clear, however, is that working memory is not completely distinct from short-term memory. It is a term that was originally

used to refer to memory as it is used to plan and carry out behavior. One relies on working memory to retain the partial results while solving an arithmetic problem without paper or to combine the premises in a lengthy rhetorical argument. Measures of working memory have been found to correlate with intellectual aptitudes (and especially fluid intelligence) better than measures of short-term memory and, in fact, possibly better than measures of any other particular psychological process (see for example Conway et al. 2005). This reflects the use of measures that incorporate not only storage but also processing, the notion being that both storage and processing have to be engaged concurrently to assess working memory capacity in a way that is related to cognitive aptitude.

But what are the relations between long-term, short-term, and working memory mechanisms? Short-term memory is derived from a temporarily activated subset of information in long-term memory. This activated subset may decay as a function of time unless it is refreshed, although the evidence for decay is still tentative at best. A subset of the activated information is the focus of attention, which appears to be limited in chunk capacity (how many separate items can be included at once). New associations between activated elements can form the focus of attention. The distinction between short-term memory and working memory is clouded in a bit of confusion but that is largely the result of different investigators using different definitions. Cowan et al. (2006) proposed, on the basis of some developmental and correlational evidence, that multiple functions of attention are relevant to individual differences in aptitudes. The control of attention is relevant, but there is an independent contribution from the number of items that can be held in attention, or its scope. According to this view, what may be necessary for a working memory procedure to correlate well with cognitive aptitudes is that the task must prevent covert verbal rehearsal so that the participant must rely on more attention-demanding processing and/or storage to carry out the task. The idea is that a working memory test will correlate well with cognitive aptitudes to the extent that it requires that attention be used for storage and/or processing. In sum, the question of whether short-term memory and working memory are different may be a matter of semantics. There are clearly differences between simple serial recall tasks that do not correlate very well with aptitude tests in adults, and other tasks requiring memory and processing, or memory without the possibility of rehearsal, that correlate much better with aptitudes. Whether to use the term working memory for the latter set of tasks, or whether to reserve that term for the entire system of short-term memory preservation and manipulation, is a matter of taste. The more important, substantive question may be why some tasks correlate with aptitude much better than others.

The distinction between long-term and short-term memory depends on whether it can be demonstrated that there are properties specific to short-term mem-

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ory; the main candidates include temporal decay and a chunk capacity limit. The question of decay is still pretty much open to debate, whereas there is growing support for a chunk capacity limit. The distinction between short-term memory and working memory is one that depends on the definition that one accepts. Nevertheless, the substantive question is why some tests of memory over the short term serve as some of the best correlates of cognitive aptitudes, whereas others do not. The answer seems to point to the importance of an attentional system used both for processing and for storage. The efficiency of this system and its use in working memory seem to differ substantially across individuals, as well as improving with development in childhood and declining in old age.

4 Temporal subitizing and temporal counting

What we are looking for is an account of our phenomenology capable of explaining why we see temporal extended phenomena, such as motions, as clear and directly as colors. The account should also indicate the extension of this extended present; it should explain why we are simultaneously capable of decomposing our auditory experience of a song in a succession of notes (point-like presents) and still composing more-than-one notes in a single present experience; the different models of our temporal phenomenology sketched above (Cinematism, Retentionalism, Extensionalism) try to give a unified account of these two phenomenological aspects, but it is always one of them reduced – and thus, in a certain sense, sacrificed – to the other. A good way to characterize our phenomenology, then, could be represented by the distinction between two different ways to temporally experience the events, inspired by the debate regarding the mental processes that allow us to transform a given perceptual input into a proper motor output.

When we think back, not only we know that event A preceded event B: we also lose the sensation of a unique temporal experience of them – we only feel them as part of an ordered stream. In our present, however, the situation is different: we can't help but subitize the contents of our perception; we can't look at a ball as being in different positions at different times: we see the motion. We can even force ourselves to consider only a point-like instant, but we can't perceive it as being so: our temporal phenomenology of the present is always extended. As in a single vision of an image there is a left and a right, in our extended temporal experience of the present we recognize an after and a before. When we see an image containing three points we subitize: we are almost immediately conscious of the fact that there are three points; if we wish, we can also focus on every one of them singularly, 'counting' them, but we can't help to simultaneously have a general vision of the figure as containing one object on the left, one in the center, one on the right. If more objects are added, however, we lose the ability to

subitize: we start to focus on little areas of the image, subitizing on those, and moving our focus (that's what we do when, for example, we group numbers as in 345,678,912).

Think of the present experience of hearing two close sounds, one much longer than the other (say, 200ms of the note DO and 100ms of the note LA). Our temporal phenomenology tells a story of one present: we had one experience, we didn't 'have time' to have an experience and then another one (when we experience the note LA, the note DO isn't in our phenomenological past: it doesn't 'feel past'); still, there is a sense in which we have experienced the different duration; it is as if our experience were simultaneously made of parts and still integral and undivided. The proposal, then, is to think of two different ways of experiencing the continuous encounter of a succession of numbers (events): on the one hand we 'temporally count' them, storing them singularly and attributing them a particular, point-like present, as in the series 1 2 3 4 5 6 7 8 9: every number is alone in its present; on the other hand we 'temporally subitize' them, directly experiencing a series of them as already being together, animated, and making the cinematic metaphor disappear, as in the series 123, 456, 789 – where 123 is a single experience of motion from 1 to 3: the total experience does not consist of three stationary image, but of a motion. When the subject subitizes, then, she 'knows' that the first note (DO x 200ms) was played before and longer than the LA, but what she experienced was a co-conscious present experience of 'DOOO-LA'; the first note wasn't in her experiential past when she heard the second one. The model should thus translate not only the two different temporal experiences famously discerned by Broad, but also the fact that we are contemporaneously aware that something is moving *and* feel it moving.

Even in the spatial case, when presented with a great number of objects, we simultaneously subitize and count: we shift our viewpoint around the display and keep track of our count, but we also tend to see subgroups of objects, subitizing them. Our temporal experience is continuously presenting us with events, and even if we are able to *count* them, storing them in order as if they were disposed in a uni-dimensional mathematical line (knowing which note is before and what is after), we also *subitize* subgroups of events, experiencing them in a co-conscious present, seeing them in a single look. When we hear three notes of a song, then, there is an immediate awareness of the auditory elements, we hear them in a single, co-conscious experience; if the notes become ten, on the other hand, we lose the overall sensation of a single experience, and at the tenth note we already feel that the first is 'past': we can't 'see' the ten notes as a single object.

The difference drawn between subitizing and counting in a temporal context could be correlated with the differences described in current literature between long-term memory and short-term and working-memory and, in partic-

ular, with attentive and pre-attentive estimation mechanisms (as suggested, for example, in Burr, Turi, and Anobile 2010). Even when subjects do not have the time or opportunity to count the number of objects in the field of view, they can *estimate* numerosity rapidly (approximate *estimation* of number has been demonstrated in humans, see for example Whalen, Gallistel, and Gelman 1999). The ability to estimate number correlates strongly with mathematics achievement (Halberda, Mazzocco, and Feigenson 2008), suggesting it is strongly linked to other number-based capacities. Estimation of numerosity is rapid and effortless but not errorless. Error increases in direct proportion to the number of items to be estimated, a property known as *Weber's law*. The *Weber fraction*, defined as the just noticeable difference or precision threshold divided by the mean, is usually found to be quite constant over a large range of base numerosities. Thus, subitizing may be nothing special, merely a consequence of the resolution of estimation mechanisms and the quantal separation at low numbers. However, this idea has not received experimental support; as Burr, Turi, and Anobile (2010, p. 20) comment, "subitizing tends to be resistant to attempts to disrupt it". In particular, it seems that subitizing depends strongly on attentional resources, while estimation of larger quantities depends far less on attentional load. Subitizing is often considered to be a pre-attentive process, while enumeration of larger numbers is considered to require attention (although this is more controversial). There has been some debate as to whether subitizing uses the same or different mechanisms than those of higher numerical ranges and whether it requires attentional resources. Recent results[9] seem to show that the mechanisms operating over the subitizing and estimation ranges are not identical, and that pre-attentive estimation mechanisms works at all ranges, but in the subitizing range attentive mechanisms also come into play. The question is thorny, but there is a good experimental base to claim that in the temporal cases discussed above there may be two different mechanisms at work.

An easy objection, at this point, would come from the request of a precise indication of the boundaries of our temporal subitizing. I don't have an answer to that, but it isn't necessarily a flaw of the model here exposed. Experiences such as 'hearing a song' strongly suggest the existence of a present temporal window – we experience-as-present a non-point-like extension of the song, but much shorter than the song itself. When we temporally subitize, we try to keep under one, general look a duration of time (for example, many notes of a song); the operation becomes harder and harder with the passage of time and the accumulation of notes, and the first notes of the song start to slide away. But not only are the boundaries between the two way to experience the events not manifest: they could also depend, for example, on how much we are inclined to focus on the single notes rather then a rhythm; on our ability to anticipate the future; on

[9] See for example Burr, Turi, and Anobile (2010).

how well we know the song, etc. My hypothesis is that there isn't an unambiguous and unique window in which we temporally subitize, then, but I think there is, however, a clear phenomenological distinction between temporal subitizing and temporal counting. The difficulty, as we have seen, could be also attributed to the limits of the working memory. Progress in the field of the distinction between the different types of memories could be relevant to better explain the phenomenological difference in the temporal case that I have sketched here. It is also crucial to underline, finally, that it would be misleading to think that the subitizing is only related to visual experiences[10]; though more immediate to understand and test, it is probably better to refer to a 'sensorial subitizing', instead of a mere visual one.

Conclusions

The question is: how is our temporal experience possible? Many conflicting elements must coexist: our present is extended, but not a *totul simul*; it has boundaries, but they are shifting and not manifest; it is part of a seamless stream, but distinct from the past and the future. My answer to the question is the identification of two different mechanisms: a temporal subitizing, a co-conscious experiential 'single look' of a temporal interval; and a temporal counting, an atomic storing operation which organizes every event in a mathematical, point-like sequence.

Given the great amount of changes and events experienced, the two mechanisms are taken to be operative always and together: we never cease to store the events encountered in a temporal line, but we also experience a subgroup of them as present. Even if we are aware that technically, from a physical-mathema tical perspective, 'the present' is point-like, our phenomenological present gathers recent events in a co-conscious experience. The two mechanisms described are at the basis of our twofold temporal experience: the awareness that every note is before and after another note, and the 'experiencing as present' of more than one note.

[10]Thanks to an anonymous referee for this useful remark.

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