A Proposed Relation between Intensity of Presence and Duration of Nowness

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Summary. It is proposed to translate the mind-matter distinction into terms of mental and physical time. In the spirit of this idea, we hypothesize a relation between the intensity of mental presence and a crucial time scale (some seconds) often referred to as a measure for the duration of nowness. This duration is experimentally accessible and might, thus, offer a suitable way to characterize the intensity of mental presence. Interesting consequences with respect to the idea of a generalized notion of mental presence, with human consciousness as a special case, are outlined. Our approach includes some features consistent with other, related ideas which are indicated.

1 Introduction

In recent years, the mind-matter distinction is often referred to in terms of *dual-aspect* or *dual-perspective* accounts. In such frameworks, the mental and the material are assumed to be aspects of an underlying non-dual entity whose ontological nature has so far resisted a unifying descriptive account. A particularly fashionable dual-perspective account refers to first-person and third-person perspectives. In the perspective of the first person, subjective experience and mental phenomena are accessible. The perspective of the third person, by virtue of intersubjective operationalization, can be utilized for a specific way to address the material domain.

If we restrict ourselves to the discussion of mind and brain, the neural, chemical, and physical processes going on in the brain are assumed to belong to the material domain, whereas subjective experiences, also denoted as *qualia*, are appearances in *mental presence*. Insofar as qualia have no referents in material reality, they are "epistemically empty" concerning this reality, in the same sense as illusions or dreams are. However, they carry another kind of epistemic content called *phenomenal content*.

As an alternative to dual-aspect or dual-perspective accounts, it has occasionally been proposed to translate the mind-matter distinction into terms of time (for more recent accounts cf. Franck, 2004, 2008; Primas, 2003, 2008): Mental presence is addressed in terms of mental time while material reality is addressed by physical time. We consider this proposal as particularly promising because time plays a substantial role in *both* the mental *and* the material domain, yet this role shows characteristic differences in the two domains. The discussion of mental time and physical time has been a central and controversial topic in the philosophy of science since Mach, Russell, Einstein, and McTaggart (cf. Reichenbach, 2000; Grünbaum, 1963; Whithrow, 1980; Denbigh, 1981; Jammer, 2006).

2 Tensed Time and Tenseless Time

There are two important ways to address and compare key features of mental and physical time. One of them, originating in the philosophy of language, starts with the notion of tense. Briefly speaking, tensed time is a notion of mental time exhibiting the regions of *past* and *future* separated by the *present now*. By contrast, physical time is tenseless and is limited to the relations of “earlier than”, “later than”, and “simultaneous with”. The other starting point lies in physics, where a number of symmetry or invariance principles can be used to characterize features of time. Such principles express what remains unchanged if particular parameters are varied. Most significant examples are time-translation invariance, time-reversal invariance, and time-scale invariance. Let us begin with a discussion of these invariances for mental and physical time in more detail.

It is well known that all fundamental laws in physical theories are *time-translation invariant*, i.e., they are independent of a particular instant in time t_{initial} serving as an initial condition for their solution. This implies that the fundamental laws are independent of the time at which their predictions are empirically investigated. In this sense the choice of t_{initial} is arbitrary, and there is no present or nowness in fundamental physical theories.

Moreover, the fundamental laws of physics are also *time-reversal invariant*. This is to say that, for any arbitrarily chosen instant $t_{\text{initial}} = 0$, their solution in one direction of time has a time-reversed copy which is equally feasible. This feature is at variance with the empirical observation of a distinguished forward direction of processes in time from $t < 0$ to $t > 0$. (Note that the notions of past and future are illegitimate in tenseles physical time.) This directedness, often called *irreversibility*, is standardly explained by particular initial and boundary conditions.

Both time-translation invariance and time-reversal invariance indicate an important difference between theoretical and experimental physics. Since every experiment is carried out at a particular date and with non-anticipative measuring instruments, both invariances are broken in experimental physics (cf. Primas, 2008). In contrast to the fundamental laws of physics, experimental physics contains, thus, the notions of nowness and irreversibility (of course without any phenomenal content as it occurs in the subjective experience of qualia).

These two notions are even more crucial, if the focus is shifted from physical tenseless time to mental tensed time. From the point of view of tensed time, including the subjective experience of temporal sequences of mental states, there are two basically unquestioned features: (i) Any stage during such a sequence refers to a *present now* that distinguishes past and future; (ii) Any such sequence is *irreversibly directed* from past to future. In addition to nowness and irreversibility in experimental physics, their *mental* significance contains the qualitative character of a subjective experience, its phenomenal content or its quale. This aspect is deliberately disregarded in any description of physical or otherwise material systems, including the brain.

Scale invariances play a role wherever there is no intrinsically prescribed unit of measure, i.e. no intrinsic length or time scale. For instance, the unit of a second in physical time measurement is arbitrary in the sense that physical processes are not organized in such a way that a second would be a distinguished measure of time. The recent literature on self-affine or self-similar structures provides a bunch of illustrative examples for scale-invariant phenomena. Time-scale invariance together with time-translation invariance constitutes a group of transformations which is called an affine group. It means that displacements in time and stretching or squeezing time intervals makes no difference for the description of the considered process.

3 Can the Intensity of Presence Be Measured?

So far we have described how a translation of the mind-matter distinction to the distinction of mental tensed time and physical tenseless time leads to characteristic though subtle differences between the two notions of time. Now we want to (i) identify general qualitative features of mental presence that can be related to properties of tensed time and (ii) look for options to express these properties in terms of tenseless physical time in order to operationalize them.

Mental presence is at the basis of all subjective experience, manifesting itself in a variety of possible ways. In this sense, presence can be conceived as a most fundamental quale, within which the appearance of more specific qualia becomes possible. The concept of mental presence as such does not necessarily imply an explicit experience *of* something, but should be understood as an immediate and implicit "being aware". This awareness does not require a self-model, let alone an explicit representation of such a self-model (self-consciousness). It may be as primitive as the "creature consciousness" that Chalmers (2000) suggests as the most primitive form of conscious experience conceivable.[3] Creature consciousness amounts to nothing but an awareness without any differentiation concerning a self that is aware and an intentional content that it is aware of. In creature consciousness, the awareness of presence and the presence of awareness coincide. Nevertheless, the presence of an awareness, however primitive and dim it may be, amounts to an experience of "how it is like to be" an experiencing subject.

Chalmers (2000) locates creature consciousness at the lowest level in a hierarchy of what he calls *phenomenal families*. The next-to-lowest level considers the distinction of sleep and wake states of consciousness, which are typically subject to circadian cycles. Within wake states one can, e.g., distinguish motivational, emotional, and cognitive states, and within those one can move to more and more specific representations with qualia. This way, a hierarchy of phenomenal contents with increasing differentiation emerges. The state of current research does not provide much concrete material to assess the levels of phenomenal families in a consistent and detailed way. However, it seems plausible to assume that the awareness of presence, which is associated with a particular phenomenal family, becomes more intense when moving up the hierarchy.[4]

Beyond these differentiations, which may be referred to as "phenomenal changes", there are two additional possibilities to grade the intensity of presence. The first one is due to the amount of *attention* with which a state of consciouness is focused at.[5] Corresponding variations of the intensity of presence are called "focal changes" and can be accomplished in a more or less controlled (voluntary) fashion, depending on the degree of vigilance. The second kind of gradation is due to the distance of a considered phenomenal content from the temporal present. Clearly, the intensity of presence is highest if a quale is just experienced, i.e. located in the now, and the intensity decreases with growing distance from the now (memory toward past, anticipation toward future). Corresponding variations of the intensity of presence are called "temporal change". They occur autonomously because the now moves independently of a subject's attentional control.

In this way, *we have identified an important interface between mental presence and temporal present, with attentional focus as a potentially moderating factor*. If the intensity of presence can indeed be related to nowness and attention, the next step is to think about possible ways how this can be fleshed out. First of all, this means that we have to think about ways in which nowness and attention can be evaluated quantitatively or at least quasi-quantitatively. If such evaluations turn out to be possible, they provide interesting candidates to study the intensity of presence, even though indirectly.

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[3] Similarly, Edelmann and Tononi (2000) speak of "primary consciousness", and Damasio (1999) speaks of "core consciousness".

[4] The notion of an *intensity of presence* does, of course, need to be defined more precisely. For more discussion see Franck (2008), and for some additional details see Metzinger (2003), pp. 184–189.

[5] A comprehensive account of the psychology of attention is due to Pashler (1998).

In the following section, we popose a way in which quantitative measures for the duration of nowness might be related to the degree of attention (Atmanspacher *et al.*, 2004, 2008a). The model is called Necker-Zeno model and was originally designed to describe the dynamics of the bistable perception of ambiguous stimuli. The model is formulated exclusively in terms of physical, tenseless time. We will therefore have to argue that the variables of the model can be related to tensed time and mental presence, thus approaching an empirical operationalization of quantifiable aspects of qualitative mental concepts.

4 Time Scales in the Necker-Zeno Model

4.1 Review of the Necker-Zeno Model

The Necker-Zeno model (Atmanspacher *et al.*, 2004, 2008a,b) is inspired by the quantum Zeno effect (Misra and Sudarshan, 1977) and describes the bistable perception of ambiguous stimuli such as the Necker cube (Necker 1832) in a formal fashion. In contrast to attempts to apply standard quantum physics to brain functioning and consciousness directly, the Necker-Zeno model is based on a generalized formal framework, particularly suited for applications *beyond* physics (Atmanspacher *et al.*, 2002). Earlier suggestions to use Zeno-type arguments for cognitive systems are due to Ruhnau (1995) and Stapp (1999).

A key assumption of the Necker-Zeno model is that the cognitive state corresponding to a perceived stimulus is updated at intervals ΔT (of the order of 30 msec to 70 msec, see below). The probability that no reversal occurs within a time period T is then given by:

$$w(T) \ = \ \cos^2(gT) \quad \text{with} \quad g \ = \ \frac{\pi}{4t_0} \quad , \tag{1}$$

where t_0 characterizes the period of the reversal dynamics without updates (of the order of 300 msec, see below). The inverse of t_0, g, determines how fast the cognitive state corresponding to a perceived stimulus decays.

Let $\{\tau_i\}_{i=0,...,N}$ be the instants at which an update of the cognitive state has been performed, and let $w(\tau_N, \tau_{N-1}, ..., \tau_1, \tau_0 = 0)$ be the joint probability that no perceptual reversal has occured from τ_0 up to $\tau_N = T$. Then

$$W(T) := w(\tau_N, \tau_{N-1}, ..., \tau_1) = \prod_{i=1}^{N} \cos^2\{g(\tau_i - \tau_{i-1})\} = \prod_{i=1}^{N} \cos^2\{g\Delta T(i)\} \ ,$$

with

$$\Delta T(i) = \tau_i - \tau_{i-1} \quad .$$

For the Necker-Zeno model we have $\Delta T(i) \ll t_0$, so we may expand the cosine up to the quadratic term:

$$W(T) \approx e^{2\ln(1-\frac{1}{2}g^2(\Delta T_i)^2)} \approx e^{-g^2\sum_{i=1}^{N}(\Delta T_i)^2} \quad .$$

Assuming a constant updating interval $\Delta T(i) = \Delta T$, we obtain

$$W(T) = e^{-g^2 N(\Delta T)^2} \quad ,$$

which means for $T = N\Delta T$:

$$W(T) = e^{-g^2 \Delta T \cdot T} \quad . \tag{2}$$

$W(T)$ is the probability that no reversal has occurred up to time T. Hence, $1 - W(T)$ describes the integrated (cumulative) distribution of "dwell times" (inverse reversal rates). It yields the following probability distribution (density) for dwell times:

$$P(T) = -\frac{\mathrm{d}W(T)}{\mathrm{d}T} = \gamma\, e^{-\gamma T} \quad , \tag{3}$$

where $\gamma = g^2\Delta T$. The mean dwell time $\langle T\rangle$ is given by:

$$\langle T\rangle = \frac{1}{\gamma} = \left(\frac{16}{\pi^2}\right)\frac{t_0^2}{\Delta T} \quad , \tag{4}$$

leading to the relation

$$\Delta T \cdot \langle T\rangle = C\, t_0^2 \quad , \tag{5}$$

where C is of the order of 1 such that t_0 is basically the geometric mean of $\langle T\rangle$ and ΔT.

In this way, the Necker-Zeno model predicts a quantitative relationship between three time scales which can be interpreted in terms of cognitive time scales (for more details see Atmanspacher *et al.*, 2004):

(i) The time between successive information updates of the cognitive state is related to the so-called *sequential order threshold* of $\Delta T \approx 30$ msec (Pöppel 1997). In the original quantum Zeno effect ΔT is the time between successive observations.

(ii) The *decay time* for a sensory input to become consciously accessible (cognitively processed) is of the order of $t_0 \approx 300$ msec (Basar-Eroglu *et al.*, 1993). In the original quantum Zeno effect t_0 is the oscillation period between the two unstable states without updates, a situation which is of more or less hypothetical character in cognition.

(iii) The observed *mean dwell time* $\langle T\rangle$ between successive reversals of competing configurations of an ambiguous stimulus is usually of the order of 3 sec (Pöppel 1997). $\langle T\rangle$ has often been referred to as a duration of an "extended nowness" that is not restricted to a point separating past and future but covers a temporal interval.

These cognitive time scales obviously satisfy Eq. (5). More detailed empirical tests of Eq. (5) are possible if one of the time scales can be measured as a function of another one, which is experimentally controllable, while the third one is considered fixed.

In this respect, a number of model predictions have been confirmed by results from experiments carried out under discontinuous stimulus presentations. Atmanspacher *et al.* (2004) showed that Eq. (5) describes the behavior of $\langle T \rangle$ as a function of interstimulus intervals (off-times) $t_{\rm off}$ greater than t_0. More recently, it has been shown Atmanspacher *et al.* (2008a) that the model describes the behavior of $\langle T \rangle$ as a function of $t_{\rm off} < t_0$ as well. These results are non-trivial since they represent opposing trends for long and short off-times, separated by a critical time scale of the order of 300 msec. Atmanspacher *et al.* (2008a) also demonstrated that the empirically observed distribution of dwell times $P(T)$ or, respectively, inverse reversal rates, is matched by the model. This can be achieved by considering an initial (transient) phase for the reversal dynamics, which is highly plausible. The initial behavior can be implemented in terms of an initial decrease of ΔT or an initial increase of t_0 up to a time after which their asymptotic values are reached.

For a cognitive interpretation of the initial phase of the reversal dynamics, Atmanspacher *et al.* (2008a) speculated that some kind of attention relaxation may be a significant factor. For instance, recent evidence (van Ee 2005, Meng and Tong 2004) for voluntary control over dwell times in the perception of ambiguous figures – as opposed to binocular rivalry – could imply a significant contribution of top-down processing – as opposed to bottom-up processing. The time scales involved should, thus, be longer for bistability in ambiguous perception. Moreover, Reisberg and O'Shaughnessy (1984) found that dwell times increase if attention is distracted, and Vickers (1972) found that dwell times are reduced by increasing vigilance.

4.2 Duration of Nowness and Degree of Attention

The elementary quale of an intensity of presence can vary in three different but not independent ways briefly introduced in Sec. 3: (a) due to a change in distance from the temporal present, (b) due to a change of focal attention, and (c) due to a change of the phenomenal family. The attempt now is to make the step from these mental characterizations to physical features that are capable of operationalizing changes of the intensity of presence in the mentioned varieties.

We propose that an interesting candidate for this purpose is the duration of nowness, measurable in the sense of a physical clock time. Note that this attempt deliberately disregards the phenomenal (qualia) features of the subjective experience of nowness and focuses on an accessible physical correlate. Thus, it does in principle not differ from disregarding phenomenal (qualia) features of the experience of color such that physical characterizations like wavelengths remain. (We argue, however, that the quale of nowness should be considered much more fundamental than, e.g., qualia of color.)

a) A change in distance from the temporal present, briefly temporal change, is simply caused by the fact that the temporal present, briefly the now, moves along with physical time. We do not discuss the question why and how the moving now is synchronized with physical time (see Primas, 2003, who focuses mainly on temporal change). The intensity of presence for a perceived phenomenon increases while approching the center of the window of nowness and decreases subsequently until it fades away when the nowness interval $\langle T \rangle$ is left.[6]

The experience that something can change at all (as a function of physical time) depends fundamentally on the experience of temporal change that is associated with the change of the elementary quale of the intensity of presence. Since temporal change is autonomous, it cannot be influenced voluntarily and, thus, cannot be used as an experimentally controllable independent variable. Although a variable size of $\langle T \rangle$ expresses that nowness intervals can have variable extension, the cause of this variability remains unclear.

b) A change of focal attention, briefly focal change, occurs always in front of the background of autonomous temporal change. But different from temporal change, the intensity of presence is now susceptible to control by attention. The Necker-Zeno model provides two options to influence the duration $\langle T \rangle$ of nowness (Eq. (5)): (1) A decreasing updating interval ΔT, corresponding to a high level of attention, leads to increasing $\langle T \rangle$ if t_0 is constant; (2) An increasing decay time t_0, also corresponding to high attention, leads also to increasing $\langle T \rangle$ if ΔT is constant.[7]

Both options, changing t_0 or changing ΔT, offer an experimentally feasible operationalization of the intensity of presence (via focal change) in terms of the duration of nowness. Focal change reduces to temporal change as voluntary attention ceases. The difference between the two kinds of change has an important subjective aspect: the experience of agency in focal change, which is lacking in temporal change. However, the capability of voluntary control also depends on the degree of vigilance: the intensity of presence in Chalmers' (2000) background states of consciousness.

Roughly speaking, there is a continuous spectrum of degrees of vigilance between wake states and sleep states within the phenomenal family of background consciousness. Falling asleep means to loose control over the focus of attention. Nevertheless, the experience of temporal change can continue,

[6] Husserl (1996) denoted these two stages as protention and retention. Varela (1999) gives a detailed account of how Husserl's concepts can be related to cognitive neuroscience and indicates the perception of multistable stimuli as a promising field in this respect.

[7] Recent results by Carter *et al.* (2005) show that $\langle T \rangle$ can in fact be enormously extended (by a factor of 1000) as compared to normal conditions. Atmanspacher *et al.* (2008a) indicated empirical evidence that an attention-driven change of t_0 is more likely to affect $\langle T \rangle$ than a change of ΔT.

for instance in dreams. In dreamless sleep, this experience is extinguished. Dreamless sleep is the lowest level that vigilance reaches in a circadian cycle. We do not know yet whether this results in an expansion or a contraction of the duration of nowness, but in principle this question is open to empirical research.

c) A change of the phenomenal family to which the experienced phenomena belong is the third option in which the intensity of presence can vary. Moving up the hierarchy of phenomenal families can to some extent be associated with a varying degree of vigilance as a measure of the intensity of presence. At higher phenomenal levels, the intensity of presence consists of both a (usually) high degree of vigilance and the intensity with which a phenomenal content is present.

Even though these issues are purely speculative at present, it is plausible to assume that the duration of nowness $\langle T \rangle$ at a low-level phenomenal family, close to what Chalmers calls creature consciousness, is smaller than at higher levels, where substantial differentiations of phenomenal content abound and require higher degrees of attention and more intense mental presence. This leads to the question at which level of "creatures" one is entitled to speak about "creature consciousness" at all. Could there be a level of "proto-mental" presence below the level of creature consciousness ? Could such a "proto-mental" presence be the fundamental and ubiquitous feature of the universe from which creature consciousness emerges at specific degrees of complexity in the organization of matter ?

4.3 Operationalizing Panpsychism ?

The doctrine that mind is a fundamental feature of the world, which exists throughout the universe, is called panpsychism (Seager and Allen-Hermanson 2001, Skrbina 2005). In a recent paper, Strawson (2006) made a comprehensive attempt to defend panpsychism, for instance he says that "everything that concretely exists is intrinsically experience-involving" (p.8). We do not intend to go into Strawson's arguments in detail here, but the quoted strong statement can easily be interpreted in a way that is very similar to the approach offered in this paper. The similarity is most clearly visible if Strawson's notion of "concreteness" is understood as "being in presence". Our notion of an intensity of presence would then be equivalent to a "degree of concreteness" in Strawson's approach.[8]

As an immediate consequence, Strawson's notion of concreteness would have to be differentiated according to temporal change, focal change, and change of the phenomenal family involved. With particular respect to the last, the question addressed at the end of the preceding subsection becomes crucial. At which level of description should we assume that creature consciousness

[8] Note that Strawson (2006) does not try to specify his notion of concreteness or even discuss its potential gradation.

enters ? There are basically two possibilities to answer this question. One of them, the standard position of panpsychism, is that some rudimentary form of mental activity is a fundamental and ubiquitous feature of the universe. In other words, something "protomental" or "protoexperiential" is engrained in *every* element of material reality.

The other possibility is that the emergence of creature consciousness in the course of biological evolution required some critical degree of complexity in the organization of matter. No specification of such a critical degree has been convincingly demonstrated so far. Moreover, defenders of standard panpsychism maintain that experience as a fundamental feature of the world is qualitatively so different from matter that it would simply be a category mistake to consider it as an emergent feature.

The key issue of full-blown panpsychism is the question of "how it is like to be" a worm, an amoeba, a cell, or a molecule. Our proposal in this regard is, first of all, to rephrase notions such as protomentality or protoexperience in terms of extremely low degrees of an intensity of presence.[9] Then, in the spirit of the arguments given above, we suggest to operationalize the intensity of presence in temporal terms. More precisely, we suggest to apply the duration of nowness $\langle T \rangle$ in order to parametrize the full spectrum between the more developed conscious experience of mammals and the much less developed "protoexperience" of simpler organisms or elements of material reality.

In this way, we avoid the necessity of responding to the metaphysical issue of where mentality or protomentality ends or starts, and replace it by the criterion of a potentially measurable size of the duration of nowness. As a consequence, we would have $\langle T \rangle \to \infty$ for the limit of a (not-yet-observed) most developed form of conscious experience, and $\langle T \rangle \to 0$ for the limit of vanishing protoexperience. It should be emphasized again, that the latter case of an extension-free now is still outside the domain of physical theory, where there is no place for *experienced* nowness (and tense) at all. Nevertheless, our proposal suggests a smooth transition to physical theory insofar as the duration of nowness as a physical correlate of the intensity of mental presence would have the appropriate limit.

5 Relations to Other Approaches

5.1 Quantum Process Ontology

Process ontology basically argues that the fundamental elements of reality are to be conceived in terms of process rather than substance. Using corresponding ideas of James and Whitehead, Stapp (2007) has developed a comprehensive framework that (1) relates this idea to quantum theory and (2)

[9] This should be compared with other ideas of how to identify hallmarks of human, mammalian, and non-mammalian "consciousness", reviewed by Beshkar (2008). See also Seth *et al.* (2005), Edelman *et al.* (2005) for the same topic.

allows a discussion of mind-matter issues. One of Stapp's key assumptions is that the conventional formalism of quantum theory (*à la* von Neumann 1932) does not need to be changed for this purpose. What he advocates, however, is (a) an ontological foundation of the standard epistemological interpretation of quantum theory by Whitehead's process ontology, and (b) an addition of psychological features pertaining to the mental domain due to James.

The fundamental elements of reality that Stapp adopts from Whitehead are called actual occasions (cf. Klose, 2008). They are endowed with mental and physical poles, thus referring to mental and material aspects of reality, or consciousness and brain, respectively, in a narrower perspective. Insofar as every actual occasion has both poles, Whitehead's ontology is a paradigm example of panpsychism. Stapp deviates from this radical version: He argues that there should be a limit below which it is not reasonable to speak of mentality, or protomentality.

Another key feature of actual occasions is that they have spatial and temporal extension. The latter, which is related to James's notion of a specious present, reflects the idea that tensed time contains a temporal present that is not conceived as a point between past and future. It has a finite duration which depends on the actual occasion concerned. Whitehead does not indicate details concerning the concrete factors that may determine the duration of the present.

A specific feature of Stapp's approach, however, can be interpreted in that way. He supposes that intrinsically unstable quantum states of neuronal assemblies (involving some 10^3 to 10^6 neurons that are functionally coupled) are stabilized by the quantum Zeno effect. The strength of this effect, on Stapp's account, is related to the attentional effort with which the mental correlate of the considered neuronal assembly is focused at. Although Stapp does not explicitly refer to the duration of nowness in this context, such an interpretation may be legitimate. It would indicate that an increased degree of attention corresponds to a prolonged duration of nowness.

This agrees with the predictions, outlined in Sec. 4, according to the Necker-Zeno model. There is, however, a significant difference between this model and Stapp's implementation of the quantum Zeno effect acting on neuronal assemblies. While Stapp refers to the Zeno effect in the sense of conventional quantum theory, the Necker-Zeno model is embedded within a generalized quantum theory (Atmanspacher *et al.*, 2002), designed to address situations *outside* conventional quantum theory in particular. The example of bistable perception as a cognitive phenomenon has been worked out independently of conventional quantum theory. The Necker-Zeno model for bistable perception provides a system-theoretic description and does not assume quantum states of the brain or parts of it.

5.2 Group Representations of Tensed Time Observables

An entirely different approach discussing tense and nowness in relation to tenseless time is due to Primas (2003, 2008). He describes tensed time in terms of a Kolmogorov structure, representing an abstract type of mental memory which defines sequential order via the growth of the set of mental events. This Kolmogorov structure is associated with a non-commutative *time observable* inducing a tenseless time variable with a distribution that has non-vanishing dispersion. The spectrum of the time variable degenerates into a dispersion-free parameter in the classical (commutative) limit.

Since the tensed time observable is not commutative, tensed time can be entangled with the time variable of the material domain even if the tensed and the tenseless system do not interact. Due to this time-entanglement, the dynamical aspects of conventional quantum physics can be described in terms of strict correlations between the tensed system and the tenseless system. In the limit of vanishing correlations, the usual equations of motion of physics are recovered with an emergent parameter time as independent variable. Time-entanglement provides a reason why mental time and physical time are synchronized.

On Primas's account, tensed time T together with its complementary observable, a frequency Λ, and a scaling parameter S are proposed to generate an affine group. Primas proposes to understand the subgroups generated by T, S and Λ, S as referring to tensed and tenseless time, respectively. For the subgroup characterizing tensed time a self-adjoint Λ is not defined and, vice versa, for the subgroup characterizing tenseless time a self-adjoint T is not defined. These features eventually express the complementarity of the mental and the physical.

The tensed time subgroup has three inequivalent irreducible representations on $\mathbb{R}$ (Gelfand and Neumark 1947) which can be understood to distinguish the cases $T = 0$, $T > 0$, and $T < 0$. This provides a natural way to break the time-translation invariance, $t \to t + \tau$, of the tensed time group by introducing a temporal present, and to break the time-reversal invariance, $t \to -t$, of the tensed time group by defining future and past.

Of particular interest in our context is the "trivial" representation $T = 0$ corresponding to the present. If the spectrum of T is not dispersion-free, $T = 0$ corresponds to an extended now. The time-scale invariance of the tensed time group can be interpreted as an invariance under scaling, $T \to \sigma T$, of the extension of the now. The motion of the now (along with physical time) is subject to a broken time-reversal invariance, i.e. is directed from past to future.

Since Primas' outline is designed on a fundamental level of description, where details of concrete systems are disregarded, the parameters in his approach remain unspecified. While the parameter τ is assumed to move along with physical time, we propose that σ could be phenomenologically determined by possible operationalizations of the intensity of presence. This amounts to fixing a time scale and breaks time-scale invariance.

In Secs. 3 and 4 we discussed variations of attentional focus as a promising candidate to implement this idea empirically. In the framework of the Necker-Zeno model, we predict that such variations lead to measurable changes of the duration of nowness. Experimental studies in this direction will open a new road to studying particular aspects of mind-matter relations.

5.3 Relaxation Processes for Neural Time Keeping

In addition to the significance of nowness in mental activity, irreversibility is a key feature of subjective experience. An approach stressing the breakdown of time-reversal invariance for the neural correlates of such experiences is due to recent work summarized by Wackermann and Ehm (2006). A quick look at the mathematical representation of dynamical laws in terms of exponential functions,

$$f(t) = e^{(i\omega - \alpha)t} \quad ,$$

where $\omega > 0$ is a frequency and $\alpha > 0$ is a damping rate, reveals basically two elementary modes of description. The imaginary part of the exponent describes an oscillatory contribution, while the real part describes a relaxation process. The general case of a combination of the two represents a damped oscillation. It is illuminating to focus on the individual components separately.

An undamped oscillation $f(t) = \exp(i\omega t)$ is clearly time-translation invariant (modulo phase), since $f(t) = f(t + \Delta t)$ for $\Delta t = 2\pi n/\omega$ and $n = 1, 2, \ldots$. However, a relaxation process $f(t) = \exp(-\alpha t)$ is not. Its integration requires that specific initial conditions, the state of the system at t_{initial}, are taken into account. Hence, t_{initial} is not arbitrary and time-translation invariance is broken. This, then, provides the temporal reference point needed for the additional breakdown of time-reversal invariance.

These observations lead to a decisive criterion for reasonable candidates of neural time-keeping mechanisms. If they are intended to serve as faithful correlates of tensed time, they must include relaxation processes. Undamped oscillations alone, i.e., strictly (multi-) periodic internal clocks, do not satisfy this criterion. Only if they are coupled with a counting mechanism for n, which again requires an integrating relaxation mechanism, are they capable of exhibiting features of irreversibility required for tensed time.

The "klepsydra model" by Wackermann and Ehm (2006) is a paradigmatic example of a model which meets the criterion of relaxation without additional ancillary mechanisms. From the conceptual perspective outlined above it is, therefore, a particularly promising theoretical model of neural time-keeping. Taking two interacting klepsydrae into account, it has been developed as far as to properly match empirical results from time reproduction experiments and determine phenomenological parameters typical for the relaxation mechanisms.

Moreover, the stochastic version of the model offers the option to introduce a time operator related to the relaxation properties of stochastic (and chaotic) systems. Such a time operator naturally links the notion of irreversibility with the notion of a now with finite extension.

References

Alais, D. and Blake, R. (2005): *Binocular Rivalry*, MIT Press, Cambridge.

Atmanspacher, H., Römer, H., and Walach, H. (2002): Weak quantum theory: Complementarity and entanglement in physcis and beyond. *Foundations of Physics* **32**, 379–406.

Atmanspacher, H., Filk, T., and Römer, H. (2004): Quantum Zeno features of bistable perception. *Biological Cybernetics* **90**, 33-40.

Atmanspacher, H., Bach, M., Filk, T., Kornmeier J. and Römer, H. (2008a): Cognitive time scales in a Necker-Zeno model for bistable perception. Manuscript available at `www.igpp.de/english/tda/pdf/neckerzeno.pdf`.

Atmanspacher, H., Filk, T., and Römer, H. (2008b): Complementarity in bistable perception. *This volume.*

Basar-Eroglu, C., Strüber, D., Stadler, M., and Kruse, E. (1993): Multistable visual perception induces a slow positive EEG wave. *International Journal of Neuroscience* **73**, 139–151.

Beshkar, M. (2008): Animal consciousness. *Journal of Consciousness Studies* **15**(3), 5–33.

Chalmers, D. (2000): What is a neural correlate of consciousness ? In: Metzinger, T. (ed.), *Neural Correlates of Consciousness.* MIT Press, Cambridge, pp. 17–39.

Carter, O.L., Presti, D.E., Callistemon, C., Ungerer, Y., Liu, G.B., and Pettigrew, J.D. (2005): Meditation alters perceptual rivalry in Tibetan Buddhist monks. *Current Biology* **15**, R412–R413.

Damasio, A.R. (1999): *The Feeling of What Happens*, Harcourt Brace, New York.

Denbigh, K.G. (1981): *Three Concepts of Time*, Springer, Berlin.

Edelman, D.B., Baars, B.J. and Seth, A.K. (2005): Identifying hallmarks of consciousness in non-mammalian species. *Consciousness and Cognition* **14**, 169–187.

Edelman, G.M and Tononi, G. (2000): *A Universe of Consciousness*, Basic Books, New York.

Ee, R. van (2005): Dynamics of perceptual bi-stability for stereoscopic slant rivalry and a comparison with grating, house-face, and Necker cube rivalry. *Vision Research* **45**, 29–40.

Ee, R. van, Dam L.C.J. van, and Brouwer G.J. (2005): Voluntary control and the dynamics of perceptual bistability. *Vision Research* **45**, 41–55.

Franck, G. (2004): Mental presence and the temporal present. In: Globus, G.G., Pribram, K.H. and Vitiello, G. (eds.), *Brain and Being.* Benjamins, Amsterdam, pp. 47–68.

Franck, G. (2008): Presence and reality: An option to specify panpsychism ? *Mind and Matter* **6**, 123–140.

Gelfand, I. and Neumark, M. (1947): Unitary representations of the group of linear transformations of the straight line. *Comptes Rendus de l'Académie des Sciences de l'URSS* **55**, 567–570.

Grünbaum, A. (1963): *Philosophical Problems of Space and Time*, Knopf, New York.

Husserl, E. (1996): *The Phenomenology of Internal Time Consciousness*, Indiana University Press, Bloomington.

Jammer, M. (2006): *Concepts of Simultaneity*, Johns Hopkins, New York.

Klose, J. (2008): Process ontology from Whitehead to quantum physics. *This volume.*

Meng, M. and Tong, F. (2004): Can attention selectively bias bistable perception? Differences between binocular rivalry and ambiguous figures. *Journal of Vision* **4**, 539–551.

Metzinger, T. (2003): *Being No One*, MIT Press, Cambridge.

Misra, B. and Sudarshan, E.C.G. (1977): The Zeno's paradox in quantum theory. *Journal of Mathematical Physics* **18**, 756–763.

Necker, L.A. (1832): Observations on some remarkable phenomenon which occurs in viewing a figure of a crystal or geometrical solid. *The London and Edinburgh Philosophy Magazine and Journal of Science* **3**, 329–337.

Neumann, J. von (1932): *Mathematische Grundlagen der Quantenmechanik*, Springer, Berlin.

Pashler, H.F. (1998): *The Psychology of Attention*, MIT Press, Cambridge.

Pöppel, E. (1997): A hierarchical model of temporal perception. *Trends in Cognitive Science* **1**, 56–61.

Primas, H. (2003): Time-entanglement between mind and matter. *Mind and Matter* **1**, 81–119.

Primas, H. (2008): Complementarity of mind and matter. *This volume.*

Reichenbach, H. (2000): *The Direction of Time*, Dover, New York.

Reisberg, D. and O'Shaughnessy, M. (1984): Diverting subjects' concentration slows figural reversals. *Perception* **13**, 461–468.

Ruhnau, E. (1995): Time Gestalt and the observer. In: Metzinger, T. (ed.), *Conscious Experience*. Imprint Academic, Exeter, pp. 165–184.

Seager, W. and Allen-Hermanson, S. (2001): Panpsychism. *Stanford Encyclopedia of Philosophy*, ed. by E. Zalta.

Seth, A.K., Baars, B.J. and Edelmann, D.B. (2005): Criteria for consciousness in humans and other mammals. *Consciousness and Cognition* **14**, 119–139.

Skrbina, D. (2005): *Panpsychism in the West*, MIT Press, Cambridge.

Stapp, H.P. (1999): Attention, intention, and will in quantum theory. *Journal of Consciousness Studies* **6**(8-9), 143–164.

Stapp, H.P. (2007): *The Mindful Universe*, Springer, Berlin.

Strawson, G. (2006): Realistic monism: Why physicalism entails panpsychism. *Journal of Consciousness Studies* **13**(10-11), 3–31, commentaries pp. 32–183, replies pp. 184–280.

Varela, F.J. (1999): Present-time consciousness. *Journal of Consciousness Studies* **6**(2-3), 111–140.

Vickers, D. (1972). A cyclic decision model of perceptual alternation. *Perception* **1**, 31–48.

Wackermann, J. and Ehm, W. (2006): The dual klepsydra model of internal time representation and time reproduction. *Journal of Theoretical Biology* **239**, 482–493.

Whitrow, G.J. (1980): *The Natural Philosophy of Time*, Oxford University Press, Oxford.