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Special issue: Research report

Ganzfeld-induced hallucinatory experience, its phenomenology and cerebral electrophysiology

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ARTICLE INFO

Article history:
Received 30 October 2006
Revised 3 March 2007
Revised 22 May 2007
Accepted 27 May 2007
Published online 5 June 2008

Keywords:
Altered states of consciousness
Electroencephalogram
Ganzfeld
Imagery
Subjective perceptual phenomena
Telepathy

ABSTRACT

Ganzfeld, i.e., exposure to an unstructured, uniform stimulation field, elicits in most observers pseudo-hallucinatory percepts, and may even induce global functional state changes ('altered states of consciousness'). The present paper gives a comprehensive overview of the phenomenology of subjective experience in the ganzfeld and its electrophysiological correlates. Laboratory techniques for visual or multi-modal ganzfeld induction are explained. The spectrum of ganzfeld-induced phenomena, ranging from elementary percepts to complex, vivid, dream-like imagery is described, and the latter illustrated by transcripts of subjects' reports. Similarities and differences to related sensory/perceptual phenomena are also discussed. Earlier findings on electrophysiological correlates of the ganzfeld are reviewed. Our own studies of electroencephalographic (EEG) activity in the ganzfeld are presented in some detail, and a re-analysis of data on EEG correlates of hallucinatory percepts *in statu nascendi* is reported. The results do not support the hypothesis of the hypnagogic origin of the percepts; the ganzfeld-induced steady-state is an activated state, and the spectral EEG dynamics in the alpha frequency range reveals processes of attention shifts and percept formation. The final section is devoted to the controversial topic of allegedly anomalous communication between human subjects ('ganzfeld telepathy'). It is shown that the use of ganzfeld in this research field relies partly on unsupported hypotheses concerning ganzfeld-induced states, partly on a weak conceptual background of the experimental procedure. The rôle of a particular belief system shared by the participants and experimenters is critically discussed.

1. Introduction

Sensory systems, i.e., structures specialised to inform the organism of certain physical properties of the environment, play an essential rôle in the behavioural integration of the organism into its 'world' (von Uexküll, 1926). A necessary condition for proper functioning of a sensory system is an adequate stimulus, where 'adequate' refers to three important aspects of the sensory input: (1) its *physical nature* must correspond to the specialised function of terminal receptors; (2) *intensity* has to fit the dynamical range of the receptors; and, in case of sensory systems mediating the 'epicritic' sensitivity (Head, 1920), (3) *variation range and structure* of the stimulus has to meet the feature-extracting and representation-building

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doi:10.1016/j.cortex.2007.05.003

capability of the central neural component of the respective system. The importance of the structural aspect of perception has been revealed by discoveries of visual contrast enhancing mechanisms, e.g., lateral interactions operating on the retinal (von Békésy, 1967; Ratliff, 1974) or cortical level (Stemmler et al., 1995). Briefly, the stimulus—or, in case of spatially distributed analysers such as the visual system, the *stimulation field*—must fall within a relatively wide but necessarily limited range in terms of its energetic and informational characteristics. Perception is the perceiving of a structure; e.g., vision is perception of the structured 'ambient optical array' (Gibson, 1979).

Of interest here are phenomena occurring when one or several sensory systems are exposed to adequate physical stimulation of *inadequate structure* or—as a limiting case—totally *unstructured*. Such situations are rather rare in our natural physical environments: for example, viewing a uniformly blue sky on a clear summer day, or vision obfuscated by a dense fog cloud illuminated by the sun from outside. Under such circumstances, perceivable patterns or even complex and structured illusory percepts may appear in the homogeneous visual field.

An early—perhaps the first?—scientific account on vision of an unstructured bright field can be found in Purkyně's (1819) pioneering study of subjective visual phenomena. Purkyně described light and dark spots occurring spontaneously "[w]hen gazing at a large field of almost blending luminance, e.g., at the sky uniformly covered by clouds, or watching a candle flame from a short distance" (Purkinje, 1819, pp. 67–68), and also similar phenomena appearing in a completely dark visual field. He compared their appearance with meteors, and speculated on their possibly electrical nature, by analogy with luminous phenomena of atmospheric electricity. Importantly, these subjective phenomena must not be confounded with images of fine anatomical structures (e.g., the 'blood vessel figure' also described by Purkyně) or microscopic bodies floating in the intra-ocular media.

A century later, perceptual phenomena occurring in homogeneous visual fields became the subject of a more systematic research, mainly due to the focus of *gestalt* psychology on the principles of perceptual organisation (Wertheimer, 1938). In opposition to the stimulus–response paradigm—borrowed from 19th century's sensory physiology and adopted by early psychology—*gestalt* psychology emphasised the active rôle of the perceiving subject in the genesis of a structured percept; hence the interest in formation of subjective percepts in absence of an objective structure imposed by the physical sensory input. The term *ganzfeld*, derived from German *ganz* = 'whole, entire' and *Feld* = 'field, area', was coined as a generic term for the unstructured visual field (Metzger, 1930). (Note that the noun *Ganzfeld* does not make much sense unless the quality fulfilling the visual field is specified; e.g., *farbiges Ganzfeld* = 'visual field entirely filled with colour'.)

Further research focused mainly on the conditions of figure-ground differentiation in the ganzfeld and colour perception (see Avant, 1965, for a review, cf. also Tsuji et al., 2004). From the middle of the 20th century on, the ganzfeld is used in diverse research contexts. In addition to the studies of perceptual organisation, the ganzfeld is used as a technique to manipulate the subjects' global mental state; specifically, to induce an artifical 'hypnagogic' state, similar to states occurring spontaneously at sleep onset (Witkin and Lewis, 1963). Following this turn towards so-called 'altered states of consciousness' (ASC), the ganzfeld has been repeatedly applied in experimental parapsychology to induce a state presumably facilitating 'telepathic communication' (Braud et al., 1975; Parker, 1975; Honorton et al., 1990). Due to this diversity of contexts and purposes—ranging from vision research to the far frontiers of psychology—the term 'ganzfeld' has lost its topically precise meaning and acquired, undeservedly, a somewhat mystical flavour.

The aim of the present paper is to provide a comprehensive overview of the phenomenology of subjective experience in the ganzfeld, as well as of its objectively measurable electrophysiological correlates, based mostly on our experimental studies of ganzfeld-induced phenomena. According to the focus of this special issue, particular attention is given to the rôle played by the ganzfeld in studies of 'telepathic communication' (or 'anomalous information transfer': Bem and Honorton, 1994), and to a critical discussion of the underlying concepts and results of that research.

2. Experimental techniques for ganzfeld induction

The term *ganzfeld* originally denoted a homogeneous *visual* field. By analogy, unstructured or de-structured stimulation can be applied to other sensory systems, e.g., auditory or tactile. Studies aiming at induction of ASC have been using 'multi-modal ganzfeld' (MMGF), i.e., simultaneous exposure to unstructured visual and auditory input.

A number of techniques have been developed to create the visual ganzfeld. The simplest method is to let the subject gaze at a uniformly illuminated surface, e.g., a large sheet of paper (Goldstein and Rosenthal, 1930) or a perfectly smooth wall (Metzger, 1930) (Fig. 1a). To ascertain the homogeneity of the visual field under minor changes of the subject's direction of view (eye movements, postural changes), smoothly curved wings can be used. In another variant, the subject watches the interior of a spherically shaped, uniformly illuminated cavity (Fig. 1b) (Gibson and Dibble, 1952).

Generally, ganzfeld stimulation rooms with planar or spherical surfaces are rather space-demanding options, and require much technical sophistication to achieve a perfectly homogeneous visual field. An inexpensive and convenient alternative is to use light diffusors mounted on the subject's head, e.g., special goggles or semi-translucent eye-shields, and illuminated by a light source from outside (Gibson and Waddell, 1952) (Fig. 1c). A simple and wide-spread technique, introduced by Hochberg et al. (1951) and routinely employed also in our laboratory, makes use of anatomically shaped halves of a ping-pong ball applied directly on the subject's eye orbits (Fig. 2), while the subjects' eyes remain open. This experimental setup yields a smooth, almost perfectly homogeneous visual field, and avoids disturbing perception of contours of the visual field (nose, cheekbones) present under the natural conditions.

In our earlier experimental studies (Wackermann et al., 2002; Pütz et al., 2006) a red-coloured incandescent 60-W

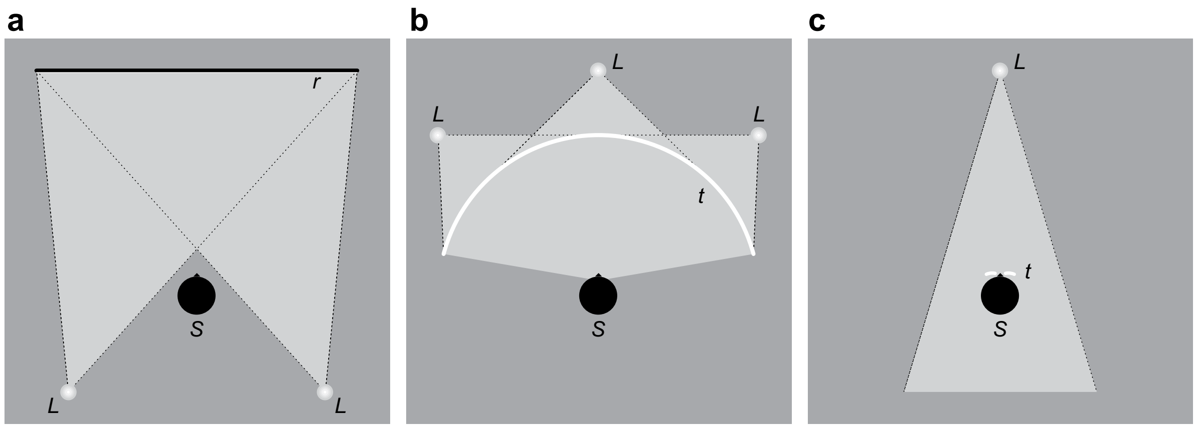

Fig. 1 – Spatial arrangements used to create a uniform visual field. S = subject, L = light source, r = reflecting surface, t = translucent material. (a) Planar stimulation field. (b) Spherical stimulation field. (c) Head-mounted light diffusors.

lamp, placed at a distance ~120 cm from the eye-shields, was used as the light source; in recent studies, where a precise control of the ganzfeld colour is important, a computer-driven, xenon lamp based D-ILA projector has been used (Pütz and Wackermann, 2007). The choice of red colour reportedly (Cohen, 1958) facilitates the observers' 'immersion' in the ganzfeld.

A wide range of acoustic stimuli has been used to homogenise sensory input in the auditory modality. The notion of perfectly unstructured sensory field is ideally met by using a broad-band, flat-spectrum noise ('white noise'), but a longer exposure to pure white noise may be annoying or irritating for many subjects; spectrally shaped 'pink noise' is a suitable alternative. Arguably equivalent results may be obtained using monotonous natural noises or sounds. In our laboratory a CD record of the sound of a waterfall, played-back to the subjects via headphones, is routinely used as the auditory component of the MMGF stimulation. A comfortable sound intensity is adjusted individually to the subject's preference prior to the experiment, and kept constant during the session.

3. Subjective experience in the ganzfeld

Three principal methods to access the subjects' experience in psychophysiological research are (a) '*post hoc' reports*, based on the subject's retrospective memory recall; (b) '*on demand' reports* initiated by the experimenter; (c) '*self-initiated' reports* by the subject her/himself. Retrospective reporting is a method of choice in exploratory studies, suitable for subjects trained in introspection (often experimenters themselves, such as Purkyně, quoted in Section 1). Its use is limited or questionable in case of mid-term to long-term alterations of the state of consciousness, including ganzfeld-induced states. The latter two methods are preferable in studies where the stream of subjective experience has to be correlated with objective physiological measurements. The 'on demand' method is easy to use and well suited to collect random samples of the subjects' momentary 'mentation' (e.g., Lehmann et al., 1995). Where a circumscribed class of phenomena is of interest, the method of 'self-initiated' reports is more economical, but requires prior training of the subjects. Observations in this section are mostly based on the 'on demand' or 'self-initiated' reports from our studies.

3.1. *Phenomenological characteristics*

Elementary changes of sensory qualities are usually observed already after a relatively short exposure to the visual or MMGF (a few minutes). The visual field's luminance diminishes and the field shows diffuse inhomogeneities, often described as a 'cloudy fog'. In case of a colour ganzfeld, the field's colour gradually bleaches, up to the point of a loss of the sensation of colour: the field is of indefinite grey, sometimes with an undertone of the complementary colour, e.g., greyish-green if red light is used. In addition, more distinct structures may appear against the diffuse 'foggy' background: dots, zig-zag lines, or more complex patterns. Generally, these elementary perceptual phenomena can be accounted for by adaptive retinal processes: saturation of the receptive elements and their mutually inhibitory interactions (Helson and Judd, 1932; Hochberg et al., 1951).

After a prolonged exposure (a few minutes up to tens of minutes) to the ganzfeld, some subjects report *complex* percepts, apparently unrelated to the above-described sensory phenomena and thus of presumably central nervous origin. Clarity and distinctness of these percepts vary inter- as well as intra-individually; they may achieve a *hallucinatory quality*, that is, vividness comparable to that of dreams or hypnagogic percepts (see below). [More precisely, we should say 'pseudo-hallucinatory' (Jaspers, 1953), since the subjects' awareness of the experimental situation and unreality of the perceived remains intact.] The occurrence of hallucinatory percepts justifies the classification of the ganzfeld-induced state as an ASC (Vaitl et al., 2005).

In most cases, *visual* phenomena largely prevail in subjects' reports, so that the term 'ganzfeld imagery' is often used as a synonym for the totality of the ganzfeld-induced subjective experience. However, almost any sensory modality may be involved (see Table 1). The next most frequently reported sensory modality is *auditory*, occurring either alone or accompanying visual percepts. The acoustic hallucinations

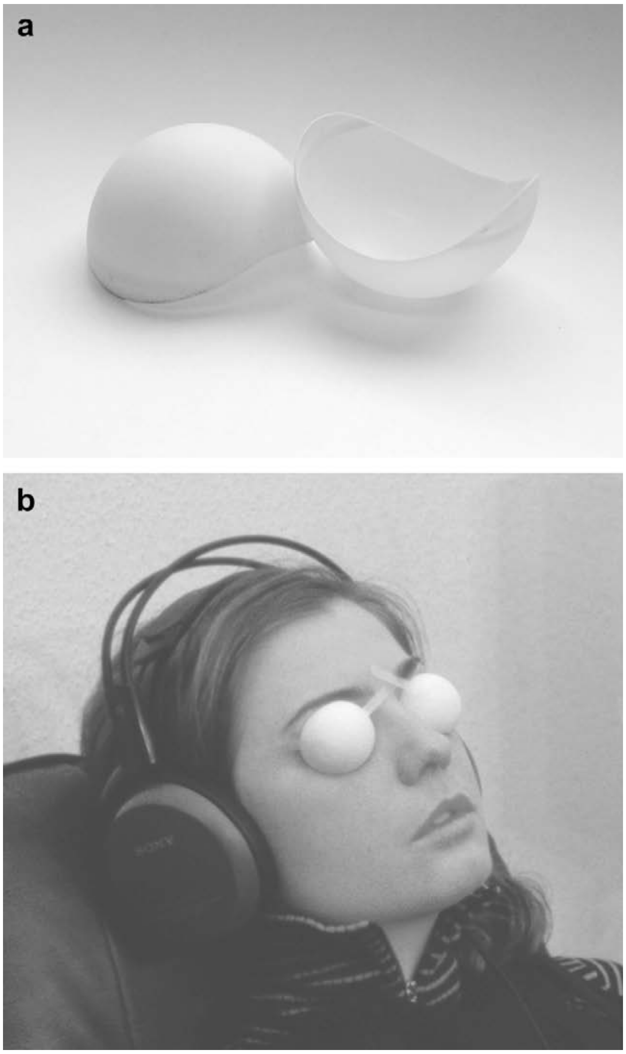

Fig. 2 – Construction of a head-set of light diffusors for ganzfeld experiments. (a) Ping-pong ball cut into two halves along anatomically shaped contours. (b) Subject exposed to multi-modal ganzfeld. (Photo A. Fischer).

may range from relatively simple (e.g., ringing bells, bursts of laugh) to complex percepts (speaking voices, musical melodies). Tactile or kinesthetic sensations, or remarkable subjective changes of the body scheme may also occur. Olfactory and gustatory sensations are only rarely reported. As it is difficult to control stimuli to these senses under normal laboratory conditions, the differentiation of truly hallucinatory sensations from technical artefacts is often uncertain (cf. Wackermann et al., 2002, p. 134), unless the reported sensations are of evidently bizzare or impossible quality.

Ganzfeld imagery is not experienced continuously but rather in *transient episodes*, sometimes developing in time to reach full clarity, often occurring abruptly. In the screening part of a study by Pütz et al. (2006), 40 subjects were trained in self-initiated imagery reporting. Seven selected 'high-responders' were then exposed to MMGF for 45 min; the numbers of imagery episodes reported per session were in the range 0–9, thus leaving (on the average) a time period of

Table 1 – Description of three studies of ganzfeld-induced imagery and occurrence of different sensory modalities in the subjects' reports

Study	I	II	III
N of subjects	12	40	7
Sessions/subject	2	1	3
Session duration	30 min	30 min	45 min
Reporting method	On demand	Self-initiated	Self-initiated
Sensory modalities reported (percent)[a]			
Visual	90	94	98
Auditory	29	16	23
Tactile	26	10	9
Kinaesthetic	—	5	2
Olfactory	16	3	4

Wackermann et al. (2002) and Pütz et al. (2006).
a Column sums exceed 100% because of percepts involving more than one sensory modality.

~5 min for the 'preparatory' phases between the episodes. Subjective estimates of the duration of the hallucinatory episodes were in the range from 3 sec to 7 min.

There seem to be inter-individual differences in the subjects' 'responsiveness' to the MMGF: distributions of report frequencies per session of fixed duration are usually U-shaped, with a local minimum separating 'high-responders' from the majority of average/low-responders (Pütz et al., 2006, 2007). Little is known by now about the psychological conditions or personality correlates of the responsiveness to ganzfeld, and virtually nothing is known about its neurophysiological substrate. Unpublished data from the study by Pütz et al. (2006) shows that the personality profiles of the seven selected high-responders, assessed by the NEO Five Factor Inventory (Costa and McCrae, 1992) differed from the rest of the pool only in personality factor 'Conscientiousness' (C). A negative correlation between individual C scores and the numbers of reports per session, ($r = -.31$, $p \approx .05$) suggests that a *laisser passer* attitude is favourable for the production of ganzfeld imagery. Interestingly, all seven high-responders were women, while the pool of unselected subjects consisted of 28 women versus 12 men.

Another phenomenon occasionally reported from the ganzfeld are episodes of "complete disappearance of the sense of vision for short periods of time", also called 'blank-outs' (Cohen, 1960), occurring after prolonged exposure (10–20 min) to the ganzfeld. Subjects also report that during these periods they were uncertain whether their eyes were open or closed, or even unable to control their eye movements. In the 'luminous fog' of the ganzfeld the subjects do not see anything; in the 'blank-out' periods, they may experience presence of 'nothingness' (Gibson, 1979).

Ganzfeld-like conditions may be met in exceptional natural environments, e.g., during high-altitude flights, exploratory journeys in mountain or desert landscapes, or practice of extreme sports. Individuals prone to hallucinatory experience in the ganzfeld may under such 'favourable' circumstances perceive unreal things and beings (cf. Brugger et al., 1999; Arzy et al., 2005). While in experimental situations the subjects are aware of the illusory character of their percepts, conditions for apprehension of percepts spontaneously occurring in the 'natural ganzfeld' may be different. Factors such as social isolation, impossibility of a direct (physical) reality check, exhaustive states or high arousal, etc. may contribute to deficient cognitive processing of the percept, thus resulting in claims of real experience of the unreal, or even the 'super-natural'. Depending on the subject's disposition and pathoplastic social or cultural factors, experience of 'blank-out' episodes may elicit even mystical or religious interpretations.

3.2. *Examples of ganzfeld-induced imagery*

Typical characteristics of visual imagery in the ganzfeld are sudden appearance and disappearance; mostly static character, but sometimes also abrupt, dynamical changes and occurrence of new elements; clarity and distinctness equaling or exceeding that of most vivid dreams. Yet, the subjects' awareness of the percepts being not 'objectively real' is preserved.

One of the authors reported on his very first experience with the ganzfeld:

> "For quite a long time, there was nothing except a green-greyish fog. It was really boring, I thought, 'ah, what a non-sense experiment!' Then, for an indefinite period of time, I was 'off', like completely absent-minded. Then, all of sudden, I saw a hand holding a piece of chalk and writing on a black-board something like a mathematical formula. The vision was very clear, but it stayed only for few seconds and disappeared again. The image did not fill up the entire visual field, it was just like a 'window' into that foggy stuff."

Shortly later, the subject had a vision of

> "an urban scenery, like an empty avenue after a rain, large areas covered with water, and the city sky-line reflected in the water surface like in a mirror."

Still during the same session, the subject saw an image of

> "a clearing in a forest [*Lichtung*], a place bathed in bright sun-shine, and the trunks of trees around. A feeling of a tranquile summer afternoon in a forest, so quiet, so peaceful. And then, suddenly, a young woman passed by on a bicycle, very fast, she crossed the visual field from the right to the left, with her blond long hair waving in the air. The image of the entire scene was very clear, with many details, and yes, the colours were very vivid."

These three reports demonstrate the most salient characteristics of ganzfeld-induced imagery, as listed above. Unlike many dreams, the examples show coherence of content and proximity to real-world situations, or could even be recollections of sensory percepts from the past (the hand writing on a black-board). Similarly to dreams, minor deviations from the material logic (how could the bicyclist ride at such a breath-taking speed in a dense forest?) are accepted without notice. Interestingly, the very first hallucinatory percept of the three reported above emerged after a 'blank-out' period.

While the introductory examples describe purely visual imagery, percepts combining more sensory modalities are no exception, as shown in the following. The texts are excerpts from subjects' reports collected in three large experimental studies carried out in our laboratory. The transcripts were translated from German to English, abridged and edited for the sake of legibility.

Some percepts are very impressive for their visual clarity and dynamism. A 54-year-old woman had a vision of a horse, as if seen face-to-face:

> "I can see his face, still, it's very expressive… [I could see] only the horse that comes as if out of clouds. A white horse that jumped over me."

As mentioned above (and documented by Table 1), visual and auditory sensations may combine to a coherent, meaningful percept, such as in the following report (woman, 36 years):

> "A friend of mine and I, we were inside a cave. We made a fire. There was a creek flowing under our feet, and we were on a stone. She had fallen into the creek, and she had to wait to have her things dried. Then she said to me: 'Hey, move on, we should go now'."

In the following example, given by a 37-year-old woman, the visual and auditory components are accompanied by a kinaesthetic sensation:

> "It was like running a bob sleigh on an uneven runway right down… [There] was snow or maybe water running down… I could hear music, there was music coming from the left side below."

The contents of the hallucinatory percepts are often familiar to the subjects, taken from their past experience but combined in an unusual way or framed into a novel context (Pütz et al., 2006). However, the reported percepts may attain a really bizzare quality, as in the following fragment (woman, 37 years):

> "In the right side of the visual field, a manikin suddenly appeared. He was all in black, had a long narrow head, fairly broad shoulders, very long arms and a relatively small trunk…. He approached me, stretching out his hands, very long, very big, like a bowl, and he stayed so for a while, and then he went back to where he came from, slowly."

Not only the appearance of the alien, but also his way of leaving the stage was spectacular:

> "There was a rock wall [decorated] with ornaments, and a white tube stretched out of the wall, and it was as if he was sucked into the tube interior. He disappeared as if flying, he was sucked smoothly into the tube."

Interestingly, a water element appeared very often in the visual imagery, e.g., lakes, creeks, streaming fluids, which is possibly related to the nature of the acoustic MMGF component, viz. the monotonous sound of a waterfall (see Section 2).

It is known from experimental studies of dreams that a simple sensory stimulus may be transformed and meaningfully integrated in the dream plot (de Becker, 1968). Thus, similar mechanisms may be at work in production of the oneiric and ganzfeld imagery. Acoustic percepts co-occurring with the visual imagery may have the form of articulated speech or music. Purely acoustic percepts are often simpler, e.g., elementary sensations of environmental sounds, unclear voices, laughter, and the like.

Finally, we should mention rather rare reports of non-visual, purely kinaesthetic or proprioceptive experience in the ganzfeld-induced state. Some subjects reported changes in their body scheme, such as extensions of their extremities, changes of perceived body weight, or even a feeling of 'levitation'; for example, a 44-year-old woman described a feeling of her body moving continuously upwards, an impression of 'ascension'. Such experiential modes do not fit the category of 'imagery', but they seem to have been really perceived, not 'just imagined', and their character clearly indicates an ASC.

4. Related sensory/perceptual phenomena

The following is an overview of experimental or natural situations in which percepts similar to those observed in the ganzfeld may occur. The aim of this section is to provide a larger context into which the phenomenology of ganzfeld can be embedded.

4.1. *Flickering ganzfeld*

Purkyně described geometrical patterns and colours occurring in a flickering visual field (Purkinje, 1819). The emergence of colours may be related to 'subjective colours' observed by Fechner (1838) on rotating disks with black/white sectors. These 'stroboscopic patterns' were later studied by Smythies (1959) who provided phenomenological classification of perceived forms: straight lines, honeycomb patterns, complex mosaics. Herrmann (2001) in an electroencephalographic (EEG) study of the visual cortex's response to a flickering visual field observed the appearance of subjective colours and forms. Herrmann and Elliott (2001) described the variety of these perceptual phenomena as a function of flicker frequency (1–40 Hz). Recently, Becker and Elliott (2006) reported co-occurrences of forms and colours in a flickering ganzfeld being dependent on flicker frequency, and phase relationship between the subject's response and the flicker period.

Analysis of these phenomena may provide a deeper insight into spatio-temporal dynamics of the retinal and/or cortical processes (Spekreijse et al., 1971; Kelly et al., 1976; Billock and Tsou, 2007) that may be related to the formation of visual structures in the static ganzfeld. In contrast to the latter, the flickering ganzfeld seems to induce a complex, spatio-temporal resonance response. Also, it is well-known that the brain's response to periodic photostimulation (PPS) may be not limited to visual sub-systems but may propagate further in the brain (e.g., photosensitive epilepsy). The global dynamics of the brain's response to PPS is thus a subject of study of its own (Wackermann, 2006).

4.2. *Dark field vision*

Luminous phenomena (phosphenes) appearing in a completely dark visual field were also described by Purkyně (cf. Section 1). A few years later, Müller (1826) described complex 'visual phantasms' appearing in the dark visual field (*Augenschwarz*), in a relaxed state with eyes closed. Elementary luminous phenomena are considered a manifestation of spontaneous activity of the visual system (cf. Hurvich and Jameson, 1966); complex visual phenomena *sensu* Müller are more likely of hypnagogic origin (see below).

4.3. *Immobilised retinal images*

The image created by the eye's optical system can be fixed on the retina by special techniques (Heckenmueller, 1965). The structure of the visual field thus remains preserved but the scanning motion due to eye movements is inhibited. Under these conditions, partial or total 'fade-outs' of the visual field may occur (Yarbus, 1967), indicating that a regular refreshing is necessary for maintaining the visual structure. We may hypothesise a relationship between these 'fade-outs' and the 'blank-out' periods in ganzfeld, where eye movements are reportedly reduced.

4.4. *Sensory deprivation*

Ganzfeld is sometimes incorrectly denoted as sensory deprivation. In sensory deprivation, the physical intensity of external stimuli is minimised, ideally in most sensory modalities (Zubek, 1969). In the ganzfeld, the sensory field is unstructured but the physical intensity of sensory input is kept at the average or even above-average level; a proper term for the ganzfeld would thus be *perceptual* deprivation. But the opposition sensory versus perceptual deprivation is merely schematic: mixed experimental designs are possible, in which the visual field is only partially blurred (Kubzansky and Leiderman, 1965). Hallucinatory percepts under prolonged sensory deprivation show features similar to elementary percepts in the luminous ganzfeld or in the dark field, e.g., transient sensations of light flashes or colours (Zuckerman et al., 1969), and, like ganzfeld-induced percepts, they may also develop to "full-blown scenes". Heron (1965) observed that with the use of opaque goggles hallucinatory percepts were initially intensified then abolished, but with translucent goggles (i.e., ganzfeld condition) the hallucinations re-appeared.

4.5. *Hypnagogic imagery*

Hypnagogic states are episodes of dream-like hallucinatory experience, occurring at sleep onset (Mavromatis, 1987), described first by Müller (1826), later given name by Maury (1848). In contrast to 'true' night dreams, which are mostly of a narrative character and develop continuously, hypnagogic hallucinations are usually rather static and occur abruptly. It has been hypothesised that hypnagogic states may be a source of accounts of nocturnal 'paranormal' experiences (Cheyne et al., 1999).

Ganzfeld-induced imagery shows a remarkable similarity to hypnagogic hallucinations. This similarity plus reported global changes of consciousness in the ganzfeld (reduced vigilance, 'blank-outs') were the basis for the hypothesis of the hypnagogic origin of ganzfeld imagery ('hypnagogic-like' states: Schacter, 1976). The hypnagogic hypothesis attained a fact-like status for decades, and only recently was submitted to serious experimental scrutiny (see Section 5).

5. Brain electrical correlates of ganzfeld-induced phenomena

Analysis of the brain's spontaneous electrical activity (electroencephalogram, EEG: Berger, 1969; Niedermayer and Lopes da Silva, 1993) is an important method in studies of states of consciousness, perceptual and cognitive processes, etc., for several reasons: (i) the brain's electrical field, reflecting the summary post-synaptic activation of neuronal populations, is a 'direct expression' of the brain's functions; (ii) there is a large empirical database on correlations between brain functional states (states of consciousness, sleep stages, etc.) and EEG characteristics; (iii) spectral analysis of EEG signals into different frequency components allows a differentiated functional interpretation; and (iv) the method permits to study the brain's functioning on a sub-second scale, or to trace the brain's state changes by means of aggregated data on a seconds scale. In spite of the contemporary trend towards 'brain imaging' via functional magnetic resonance, EEG is still the method of choice, providing superior temporal yet moderate spatial resolution.

However, EEG studies of ganzfeld-induced states have been relatively rare. Reported effects where mostly related to *alpha activity*, which is a term for a regular rhythmical activity at frequency ~8–12 Hz, occurring usually in a no-task no-stimulation relaxed state, e.g., with eyes closed (Berger, 1969). Those early studies usually referred to the alpha rhythm as a unitary phenomenon. However, later studies revealed functional differences between sub-bands within the alpha frequency range: low-frequency alpha, reflecting rather attentional processes, and high-frequency alpha reflecting cognitive processes (Klimesch, 1997, 1999; cf. also Shaw, 2003). This functional differentiation may be also relevant for the interpretation of EEG-based findings on the ganzfeld.

Cohen and Cadwallader (1958) reported correlation between higher alpha activity in the resting EEG and individual susceptibility to 'blank-outs'. Cohen (1960) interpreted occurrence of alpha activity during the 'blank-outs' as alpha rebound—this is a well-known phenomenon where, after a transitory suppression e.g., due to an external stimulus, eyes opening, etc., alpha activity attains the original level, or even increases. Tepas (1962) found an increase of alpha amplitude during the 'blank-outs', which was intermediate to 'eyes closed' and 'eyes open' conditions, but could not confirm the hypothesised relation between high alpha activity and blank-out susceptibility. These findings are in line with early observations by Adrian and Matthews (1934), who had previously reported alpha rebound after eyes opening in a uniform visual field. Later, Lehtonen and Lehtinen (1972) also reported re-occurrence of alpha activity in the ganzfeld, comparable to the 'eyes closed' condition. Increase of alpha activity was also observed during the 'fade-out' periods in perception of stabilised retinal images (Lehmann et al., 1967); this supports the relation to ganzfeld 'blank-outs' hypothesised above.

As shown in the preceding sections, the variety of ganzfeld-induced phenomena is fairly rich and suggests relations to several different classes of perceptual phenomena and/or states of consciousness. Objective characterisation of the brain's functional states under ganzfeld stimulation by means of EEG measures may help to elucidate these relations. This was the objective of our two major ganzfeld studies, results of which are summarised below.

5.1. *EEG spectral signatures of the ganzfeld-induced steady-state*

A study by Wackermann et al. (2002) aimed at a comparison of the ganzfeld-induced state with the hypnagogic state at sleep onset (i.e., transition waking–sleep stage 1–sleep stage 2). EEG data recorded in different states of consciousness were compared: day-time relaxed waking, ganzfeld exposure, waking before sleep onset, and sleep stages 1 and 2. Subject's eyes were closed in all conditions except ganzfeld exposure. [Admittedly, this fact imports an inhomogeneity in the experimental conditions. There is recent experimental evidence that eyes-open and eyes-closed conditions are not equivalent even in the absence of any visual input (Marx et al., 2003). This topic deserves more attention in studies on visual imagery.]

As expected, sleep states on the one hand and waking states on the other hand showed clearly different spectral profiles (Fig. 3). The spectrum of the ganzfeld EEG is very close to that of the relaxed waking state EEG, and it is clearly different from that of sleep onset, where the alpha peak is absent. Evidently, the ganzfeld-induced brain functional state differs from the brain state at sleep onset; therefore, it is unlikely that ganzfeld-induced hallucinations were of hypnagogic nature. Within the waking states, the ganzfeld and 'normal' waking states were best distinguished by the band power ratio α_2/α_1 (frequency ranges 10–12 Hz and 8–10 Hz, respectively), which was increased in the ganzfeld EEG, indicating an acceleration of the alpha activity. Visual inspection of the spectra reveals a power drop along the lower flank of the alpha peak in the ganzfeld EEG, leading to an increase of the peak frequency (Fig. 3).

5.2. *EEG spectral signatures of ganzfeld-induced imagery*

A study by Pütz et al. (2006) specifically addressed correlates of ganzfeld-induced imagery, using the method of self-initiated reports. EEG was recorded in 19 channels during continuous ganzfeld stimulation, and subjects were asked to signal hallucinatory episodes by a button press, followed by a verbal report. Spectral characteristics of EEG recorded during ganzfeld imagery (GFI), i.e., epochs up to 30 sec before a subject's report, were compared to EEG during the ganzfeld baseline (GFB) condition, i.e., epochs more than 120 sec before a report. Using the α_2/α_1 band power ratio as the variable of interest, the authors found a tri-phasic pattern of spectral changes related

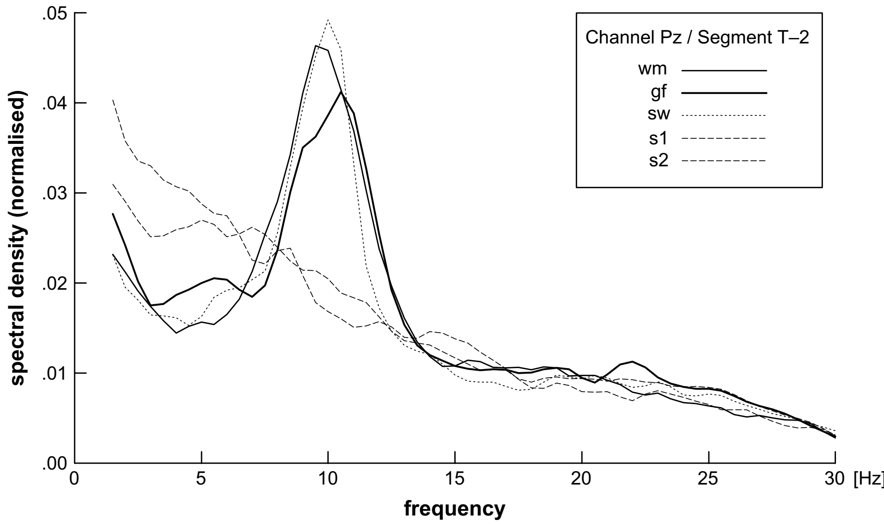

Fig. 3 – Fourier spectra of 2-sec EEG epochs recorded from the parietal region prior to 'on demand' reports of subjective experience in five different states: wm = relaxed waking state; gf = multi-modal ganzfeld; sw = waking state before sleep onset; s1, s2 = sleep stages 1 and 2. Source: Wackermann et al. (2002, p. 134); reprinted with permission from Elsevier Science.

to ganzfeld imagery, with the maximum alpha acceleration in the time segment 20–10 sec before the report. A time–frequency analysis of the data gave additional evidence for alpha acceleration (Wackermann et al., 2003). A frequency domain principal component analysis (PCA) revealed a component reflecting the shift from the lower to the higher alpha band accounting for ∼6% of the variance in single-epoch spectra of imagery-related EEG (relative to the baseline condition (Fig. 4, curve #3)). Original, unrotated PCA solution is shown. Interestingly, earlier factor-analytical studies of EEG spectra by Rösler (1975) and Mecklinger and Bösel (1989) revealed two independent components within the alpha band.

5.3. *Time–frequency dynamic of imagery-related EEG*

To further elucidate the EEG spectral changes corresponding to ganzfeld imagery, for the purposes of the present paper the same data set was re-analysed, investigating in detail the time-course of changes preceding subjects' reports. The data consisted of three recording sessions for each of seven subjects. The analysis was performed on artefact-free 2-sec epochs (512 samples) with 1-sec overlap, collected into two conditions, GFB and GFI, defined by the time relative to the subject's next report (see above). EEG spectra were computed via Fourier transform, using a Hamming taper. Baseline

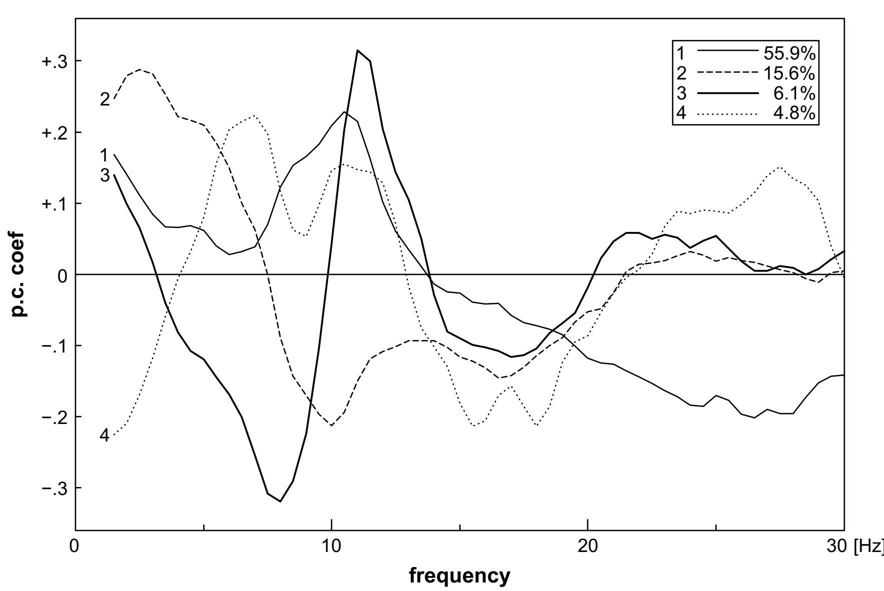

Fig. 4 – Principal components of imagery versus baseline differences between log-transformed normalised EEG spectra; data merged from 19 scalp locations according to the 10/20 system. Plotted are coefficients of four eigenvectors associated with greatest eigenvalues, i.e., contributions to the total variance (see the insertion), as functions of frequency.

spectra revealed very similar individual alpha peak frequencies (range 10.5–11 Hz) for six of seven subjects; one subject showing a deviant alpha peak frequency (8 Hz) was excluded from further analyses. Statistical evaluation of the between-conditions difference over sessions showed a significant decrease in power for GFI versus GFB mainly in the lower alpha range (~7–10 Hz). For a detailed examination, single session data were selected into two smaller data sets, (a) and (b); the selection was based on the similarity of their spectral profiles with the overall average according to visual inspection. The typical spectral forms are shown in Fig. 5 (scalp location P_z). In both cases, in the imagery-related EEG the power in the lower alpha range (~7–10 Hz) is reduced, leading to a shift of the alpha peak to a higher frequency; in addition, EEG spectrum (a) shows a local power increase at the upper bound of the alpha range, ~13 Hz.

For each data set, the average spectra of EEG epochs at the same time coordinate (i.e., time remaining to the next report) were computed, resulting in a spectrogram representation (Fig. 6, upper panels). Local maxima of the spectra were determined, and the estimates of the peak frequencies were refined using a three-point quadratic interpolation (Fig. 6, lower panels).

In data set (a), along with a relatively stable primary local maximum at ~11 Hz (the alpha peak), frequent secondary and tertiary maxima in the range 12–14 Hz are observed. The time period immediately preceding the subjects' reports (~20 sec) is characterised by a power decrease in the range below 10 Hz as well as a complementary increase in the range of secondary local maxima at higher frequencies, but not a peak shift. The redistribution of local maxima accounts for the secondary local maximum visible in the GFI average spectrum in Fig. 5a. In data set (b), alpha peak frequencies are scattered over a broader range. The time period before the subjects' reports is characterised by an overall power decrease and by a general shift towards higher frequencies. This process starts at about 60 sec before the subject's report, possibly followed by an additional shift in the last 10 sec. In summary, the generally observed alpha acceleration effect can be individually realised in at least two different forms: (a) as a slight dislocation of the barycenter of the spectral distribution which preserves the location of peaks, or (b) as an increase of the local alpha peak frequency, a real shift.

5.4. *Correlations with experiential data*

Subjects' reports were followed by a short structured enquiry, in which the participants rated qualitative properties of the reported percept on several ordinal scales (for details see Pütz et al., 2006, p. 169). These experiential data were correlated with GFI–EEG spectra and revealed various forms of 'correlation profiles' over the analysed 30 sec time window. The most stable correlation over this time window was a global (i.e., involving all 19 channels) negative correlation between α_2 power, measured relative to individual GFB baselines, and subject-reported vividness of imagery.

The relation between fast α_2 activity and imagery formation was interpreted by Pütz et al. (2006) as an indicator of activation of thalamo-cortical feedback loops involved in retrieval, activation and embedding of memory content in the ganzfeld-induced imagery. The observed α_1 attenuation during the analysis epoch may reflect a shift of attention towards the visual percept and, later, preparation of the required motor action (button press signalling occurrence of imagery). The unspecific alpha-inducing effect of the ganzfeld-induced steady-state (no imagery) is in line with the inhibition hypothesis (i.e., alpha synchronisation due to inhibition of cortical areas related to external sensory information processing), and with earlier findings of other authors mentioned above.

5.5. *Global properties of brain functional states under ganzfeld stimulation*

Global descriptors (Wackermann, 1999; Wackermann and Allefeld, 2007) of the 19-channel EEG data from the study by Pütz et al. (2006) were evaluated for the conditions GFB and GFI (baseline versus imagery, see above), and for the resting state with eyes closed. No significant difference in global field strength (Σ) was found; global generalised frequency (Φ) was increased in both ganzfeld conditions, reflecting the above-described alpha acceleration. Global spatial complexity (Ω) was higher in both ganzfeld conditions than in the idling state, and inter-hemispheric complexity deficit (Wackermann, 2003)

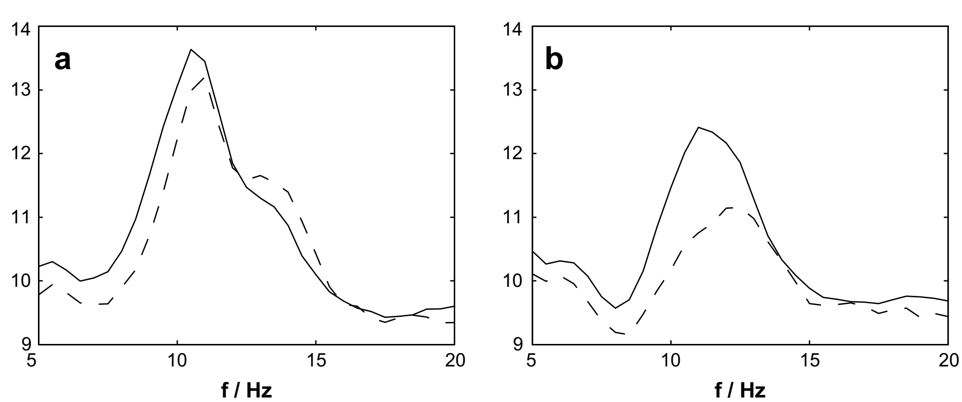

Fig. 5 – Fourier spectra of two selected subsets of EEG data recorded from P_z in the baseline condition (GFB, solid line) and within 30 sec before imagery report (GFI, dashed line). (a) Subject 1, session 2. (b) Subject 6, sessions 1–3. The vertical axis shows the logarithmic variance contributions from frequency bins of .5-Hz width.

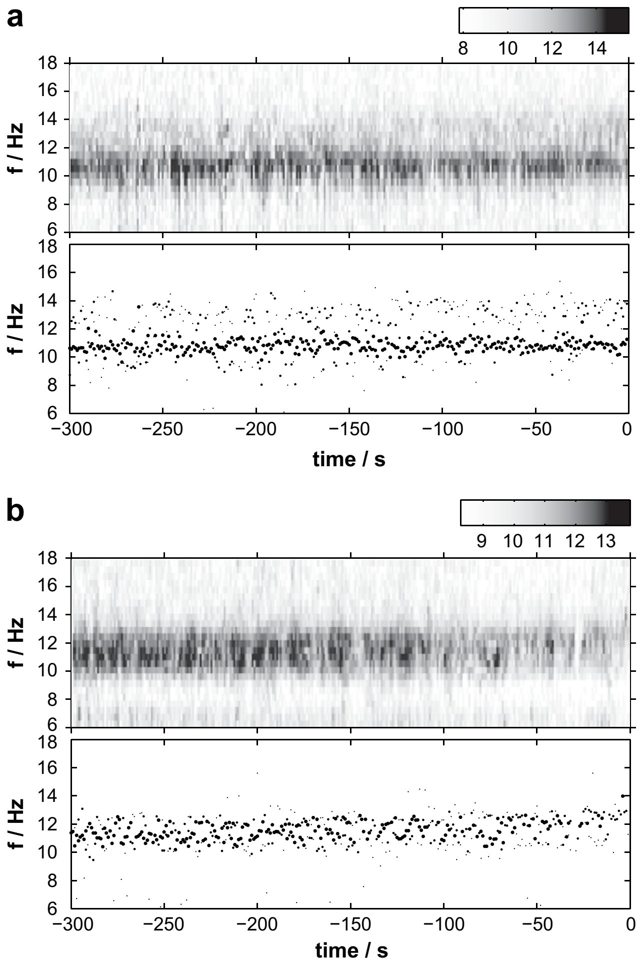

Fig. 6 – EEG spectral changes in the alpha frequency range, over time relative to the next subject report, for two selected data subsets as in Fig. 5. Upper panels: spectrogram representation, logarithmic variance contributions from frequency bins of .5-Hz width. Lower panels: peak frequencies of the 1st, 2nd, and 3rd highest local maxima, indicated by dots of large, medium or small size, respectively.

was reduced. These findings indicate higher diversity of brain activation processes and reduced inter-hemispheric cooperation as conditions that are probably favourable for emergence of internally generated imagery (Pütz and Wackermann, 2004).

5.6. *Intracerebral sources of ganzfeld-related EEG activity*

Faber et al. (2002) re-analysed data from the study by Wackermann et al. (2002) to localise intra-cranial model sources of EEG activity (frequency band 2–30 Hz). The source locations during sleep onset differed significantly from those during waking state and in the ganzfeld; there were no significant differences between the ganzfeld and waking state.

Results of reported original studies and *post hoc* re-analyses thus do not support the hypothesis of the hypnagogic origin of ganzfeld imagery. The subtle but objectively demonstrable differences between frequency spectra of the brain's electrical activity during the MMGF exposure and the relaxed waking state indicate rather an *activated* state, in which the subject's attention is directed towards the emerging percepts. Therefore, we have proposed a term *hypnagoid states* to cover a broad class of ASCs that are characterised by spontaneously dream-like imagery, and may or may not be associated with reduced vigilance (Wackermann et al., 2002; Vaitl et al., 2005).

Given the increasing body of findings on neural correlates of hallucinatory percepts of psychotic origin (e.g., Behrendt and Young, 2004; Collerton et al., 2005; Weiss and Hecker, 1999), a comparison with ganzfeld-induced pseudo-hallucinations would be of interest. We are, however, not aware of any study comparing the ganzfeld-induced states to other hallucinatory states, pathologically caused or experimentally provoked by different methods.

6. Anomalous communication in the ganzfeld?

The ganzfeld's potential to induce an ASC producing vivid imagery has been utilised by experimental parapsychology in a so-called 'ganzfeld telepathy' (GFTP) paradigm (Honorton and Harper, 1974; Braud et al., 1975; Parker, 1975). Historically, this experimental paradigm resulted from two convergent yet distinctly different developmental lines: studies on 'spontaneous psychic phenomena', reportedly occurring often in ASCs, and experiments with 'dream telepathy' in the early 1960s (Ullman et al., 1989). Following the hypothesis of the hypnagogic origin of ganzfeld imagery (Witkin and Lewis, 1963; Bertini et al., 1969), the ganzfeld was considered "a simpler and cheaper technique" compared to the dream studies (Parker, 2005).

6.1. *Experimental procedure*

In a typical GFTP experiment (Honorton et al., 1990), there are two subjects, a 'sender' (*S*) and a 'receiver' (*R*), located in two different rooms and thus spatially and sensorily separated from each other. Subject *R* is exposed to the MMGF and is reporting her/his subjective experience; simultaneously, subject *S* is focusing her/his attention on a 'target' stimulus, usually of visual content: a static picture (photograph or drawing) or a short video sequence. The aim of the experimenters is to establish a 'communication' between *R* and *S*: subject *S* is assumed to 'transmit' her/his mental content to subject *R*, where it should appear (in a manifest or a disguised form) in subject *R*'s reported imagery.

In the standard experimental setting, subject *R* is allowed or even encouraged to verbalise continuously her/his 'mentation' (percepts, thoughts, emotions, etc.), and the stream of verbal reports is recorded for later evaluation. This makes a substantial difference to the more formalised reporting methods in psychophysiological experiments, as described in the preceding sections. Also, it is unclear if and how the genuine ganzfeld-induced imagery is differentiated from merely cognitive ingredients (free associations of thoughts, reflections of daily concerns, etc.). One or more communication trials may be carried out during one experimental session.

The evaluation of a communication trial is based on (a) *direct target identification* by subject S; or (b) *assessment of similarity* between the stimulus and subject S' own experience; or (c) *assessment of similarity* between the stimulus and subject S' verbal reports recorded during the MMGF session, done by an external 'judge'. Whatever the evaluation method, the results are usually presented in the form of 'hit-rates', i.e., relative frequency with which the target could be correctly identified in an array of m alternatives ($m = 4$ used as a standard). Correct identification rates significantly exceeding the mean chance expectancy $= 1/m$ (=25% in standard designs) are considered as suggestive or indicative of the 'telepathic communication' in the ganzfeld.

The claims of positive results of GFTP studies are thus based on statistical evaluation of *series* of experiments. This poses a serious problem for the interpretation of results of single trials, and their possible linking with objective, e.g., psychophysiological measurements. Even if the 'hit-rate' from a certain study is 'significantly' higher than the mean chance expectancy, it is virtually impossible to indicate which correct identifications were due to the alleged dyadic communication and which were 'successful' merely by chance. Facing this difficulty, some authors (e.g., Parker, 2000) pointed out the importance of so-called 'qualitative hits', i.e., real-time coincidences between the contents of the target stimulus at subject *R* and the stream of verbal report given by subject S (cf. Goulding et al., 2004). However, evaluation of such coincidences is necessarily matter of subjective judgment, and thus may involve some arbitrariness.

Bem and Honorton (1994) summarised results of 10 GFTP studies carried out by Honorton and his colleagues during the period 1983–1989 that yielded an overall 'hit-rate' of 32%, significantly higher than the 25% expectancy. The authors considered these results as a ''replicable evidence for an anomalous process of information transfer''. However, their findings were questioned by a later meta-analysis of a larger GFTP database (Milton and Wiseman, 1999), which elicited further discussion between the advocates and the critics of GFTP research. It is not the aim of the present paper to go into details of the debate; an interested reader is referred to the cited papers (see also Bem et al., 2001 and Storm and Ertel, 2001). Briefly, no agreement has been reached yet: at present as well as a decade ago, GFTP is far from being acknowledged by the scientific community as an experimentally established fact.

6.2. Theoretical background

Experimental parapsychologists assume that ganzfeld induces in the 'receiver' a 'psi-enhancing' (Honorton, 1977) or 'psi-conducive' state (Bem and Honorton, 1994; Parker, 2005) favourable for the alleged telepathic communication. The term 'psi' was proposed by Thouless and Wiesner (1948) to denote the totality of 'psychic' phenomena, under the assumption that ''telepathy, clairvoyance, and precognition [...] might be the same capacity working under different circumstances''; it was originally purely descriptive as ''it implied no theory about the psychological nature of the process'' (Thouless, 1972). According to Stanford (1977), the term 'psi-conducive' was originally coined by W. G. Braud. Stanford himself distinguished between research ''in naturalistic contexts'' and laboratory research focusing on ''the search for experimental procedures which will optimize the function of the organism for the purpose of deliberate extra-sensory performance of the perceptual cognitive sort. [...] Research in this area seems to be guided by the concept of a *psi-conducive syndrome*'' (Stanford, 1977, p. 826; emphasis by author).

However, the term 'psi-conducive state' is too vague and useless for any theoretical reasoning, as long as it is tautologically defined by a success of telepathic communication, or occurrence of a 'psi' phenomenon. The terminological confusion is aggravated by some authors' using the adjective 'psi-conducive' not only for the 'receiver's' psychophysiological state, but with virtually any component of the experimental setup. For example, Parker (2005) speaks not only about ''psi-conducive techniques'', but also ''psi-conducive subjects'', and even ''psi-conducive experimenters'' (*sic*!). Another, more specific concept is thus needed to provide a rationale for the GFTP paradigm.

Honorton (1977) coined the term *internal attention states* to designate ''any condition in which conscious awareness is maintained in the absence of patterned exteroceptive and proprioceptive information'' (Honorton, 1977, p. 435). Later and elsewhere, the attenuation of external sensory stimulation is also referred to as 'noise reduction' (Honorton, 1977; Parker, 2005). The choice of this expression suggests an implicit signal-detection model: the 'anomalous information transfer' from S to *R* is considered as a weak 'signal' obscured by sensory input of higher magnitude, considered as a disturbing 'noise'. How this signal-like transfer should be realised, and what is the mechanism of its conversion into reportable subjective experience, remains unclear and open to speculations. For example, Parker (2001, p. 28) pointed out that ''misperceptions [in psi-mediated communication] occur like those in normal perception'' and hypothesised that ''psi shows the same form of top–down processes as occur in normal perception during non-optimal conditions''.

But even if one accepts the 'noise reduction' hypotheses, this begs a question: why should inundation of two main sensory systems, the visual and the auditory, effectuate anything like 'noise reduction'? In fact, it would be more rational to create for subject *R* conditions of complete sensory deprivation.

Reasoning in terms of sensory physiology is obviously not very helpful in the domain of presumably extra-sensory communication. The construction of the GFTP paradigm becomes understandable rather out of the ganzfeld's ability to induce an imagery-productive ASC. Honorton (1977, p. 459) emphasised that ''ganzfeld stimulation is associated with increased attention to internal mentation'', and accepted the (unverified) assumption of the hypnagogic nature of ganzfeld imagery; but he simultaneously pointed out (with Naranjo and Ornstein, 1971) similarities between ganzfeld and concentrative meditation, and suggested a parallel between the ganzfeld-induced 'blank-outs' and meditation-induced 'periods of void' (*ibid.*). The notion of 'internal attention states' thus seems to be broad enough to embrace productive states of vivid dream-like imagery as well as meditative experience of nothingness. Too broad, indeed; we are facing a rather confusing multitude of references to a wide spectrum of ASCs, as illustrated by the following quotation: ''The ganzfeld protocol's combination of mild sensory deprivation, the provision of an undifferentiated visual and auditory field, and relaxation provides the same combination of ideal conditions [as] described for hypnosis and dreaming…'' (Carpenter, 2005, p. 85).

In sum, the experimental technique developed for GFTP studies is neither sufficiently justified by the 'internal attention state' or 'noise reduction' hypothesis, nor well grounded in the established knowledge on the ganzfeld and its psychophysiological effects. The experimental findings contradicting the hypnagogic hypothesis of the ganzfeld-induced phenomena have been either ignored by the parapsychology community, or dismissed as untrustworthy. Parker (2005) pointed out several ''shortcomings'' of the study by Wackermann et al. (2002): discomfort of the EEG electrodes (*sic*!), no prior experience, no special relaxation sessions before experiments, and shorter MMGF exposure. However, in the later study by Pütz et al. (2006) the subjects participated repeatedly in MMGF sessions, had enough opportunity to accommodate to the experimental situation, and the sessions duration was extended to 45 min (the 'discomfort' issue does not deserve discussion), and the appearance of EEG spectra under MMGF stimulation confirmed the findings from the earlier study.

6.3. *Working alliance: a shared belief system?*

As seen above, a GFTP experiment is of quite a complex design, and little is known of the importance of its particular components; e.g., the choice of the target material, the physical characteristics of the ganzfeld stimulation, the duration of the ganzfeld exposure, physiological conditions and psychological characteristics of the participants, etc. Systematic variation of experimental conditions would be necessary to elucidate their relative contribution to the alleged anomalous communication. There are, however, factors that are generally thought of as being critically important: one of them is the participants' acceptance of, or just belief in, the reality of 'psi phenomena'; the other is the concept of the experimental situation as a 'social ritual'.

There is no doubt that the subjects must admit at least a possibility of the telepathic communication between S and R in order to actively participate in a GFTP experiment. This implies an attitude of positive *expectation*, which is further reinforced by subject *R*'s experience of imagery in the ganzfeld. As far as we know, novice participants in the GFTP experiments have no prior experience with ganzfeld in a non-dyadic setting—in other words, they *do not know* that their imaginary percepts would occur even without the S's presence and her/his efforts. The occurrence of the hallucinatory percepts plus the expectation of a 'transmission from out there' creates conditions for a self-reinforcing belief, which is welcomed and shared by the experimenters themselves.

This cognitive and emotional closure seems to be the essential component of the *working alliance* between the participants and the experimenters. Honorton et al. (1990) and Bem and Honorton (1994) emphasise the importance of a 'warm social ambiance' and conclude, ''[w]e *believe* that the social climate created in psi experiments is a critical determinant of their success and failure'' (Bem and Honorton, 1994, italics ours). It seems that all parties involved in the experiment need a sort of belief: the participants, the experimenters, even the (meta)analysts of the data. Other leading researchers in this area go even farther and plea for ''returning the magic to the laboratory'' (Parker, 2005). This is really a non-standard notion of the experimental situation, at least for those among us whose understanding of experiment has been shaped by physical sciences.

But is the belief of importance of 'acceptance of psi', 'warm ambiance', and 'atmosphere of magic' really substantiated by empirical data? In a recent study by Pütz et al. (2007), the experiment was in principle designed by the GFTP model, but presented to the participants as two parallel, unrelated experimental tasks. The subjects were thus not aware of the 'telepathic communication' possibly involved and not intending any 'transfer'. Accordingly, the subjects were not instructed to 'identify' the target stimulus (short video sequence) but they were just asked to evaluate similarity between their subjective experience in a MMGF session (20 min/trial) and four different video sequences shown to them thereafter. Trials in which the subjects assigned the highest similarity score to the stimulus which was really presented to the other member of the pair were counted as 'correct identifications'. The rate of 'correct identifications' of the target stimuli was 32.5%, that is, significantly above 25% as expected by chance ($p \approx .04$).

This result, if it were obtained in a 'standard' GFTP experiment, could be interpreted as indicative of anomalous information transfer; but is such an interpretation feasible in a situation where there is no intent of communication at all? Or does the ganzfeld-induced ASC increase the subject *S*'s unspecific 'extra-sensory sensibility' to distant stimuli in her/his environment, even without participation of the other subject (*R*)? The importance of the subjects' active involvement in telepathic communication, and of their belief in the paranormal, 'psi', and the like, has been certainly questioned; the problem deserves further experimental investigation.

7. Concluding notes

The discovery of the ganzfeld—an experimentally created visual 'nothingness'—opened views to a plenitude of interesting perceptual phenomena that have been studied from various research perspectives: sensory physiology, psychology and psychophysics, psychology of consciousness, and even parapsychology. The multitude of approaches reflects the multi-levelled organisation of the neural substrate of the ganzfeld phenomena. Conceptually, we should distinguish (a) ganzfeld-evoked sensory phenomena from (b) subjective experience characterising ganzfeld-induced global state change (deep relaxation, possibly diminished vigilance), which may range up to (c) genuinely hallucinatory imagery. Practically, the boundaries between these groups of phenomena are rather blurred and often left to the observer's interpretation. While phenomena sub (a) belong to the domain of sensory physiology, phenomena named sub (b and c) are of broad interest to neuro- and psychophysiology as well as to psychology of ASC.

The use of the ganzfeld in studies of 'anomalous communication' is a rather special chapter. Due to the proof-oriented, empiricist tradition of experimental parapsychology on the one hand, and its rather weak conceptual background on the other hand, this line of research has been situated in relative isolation from other scientific disciplines. Integration of the existing knowledge on neurophysiology of ganzfeld-induced phenomena is desirable if a progress in this still controversial domain of study is to be achieved. In the context of this special issue, the insistence of parapsychologists on a shared belief system as a background of the 'working alliance' between the participants and the experimenters is especially interesting. More research is needed to explore the rôle played by particular components of the complex experimental setup. For the time being, we remain reservedly open to the possibility of yet unexplored ways of inter-individual communication; but we stay equally open to the possibility that future research may not validate the GFTP hypothesis; alternative ways of explanation of the reported results may be sought.

Finally, we should point out that the ganzfeld provides an inexpensive, non-invasive, and (as to our knowledge) risk-free method to induce hallucinatory experience in normal subjects. As such it may serve as a suitable model for experimental research on neural correlates of hallucinations, with possibly relevant output for e.g., clinical neuropsychiatry and related fields. Very little is known still about the psychological and neurophysiological basis of responsiveness to ganzfeld. We can only speculate that the latter may be related to a proneness to spontaneous occurrence of hallucinatory states or other forms of psychopathology: another potentially promising area of research.

Acknowledgements

The authors wish to thank all earlier collaborators and assistants in the experimental studies reported in the present paper: Simone Büchi, Daria Kaluza, Nicole Rechsteiner, Frauke Schmitz-Gropengießer, and Jakub Späti. We are also thankful to Andreas Fischer for taking photographs of the ganzfeld setup (Fig. 2b), to Matthias Gäßler for technical assistance, and to two anonymous reviewers for their critical comments and helpful suggestions.

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