

VR Video Game-induced Psi Communication With Red and Green Ganzfeld: A Proof-of-Principle Study

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Abstract – In this proof-of-principle study, we intended to employ the ganzfeld psi method with two novel features. (1) We used a set of four different interactive video games randomly selected for each trial to be played in a virtual reality (VR) setting by the sender, while the receiver was wearing goggles producing either (2) a red or green ganzfeld, randomly selected. $N = 48$ young couples in a romantic relationship were recruited as sender-receiver pairs, resulting in 48 trials. Regarding the main confirmatory hypothesis, across all trials the experiment registered 15 hits out of 48 attempts, where the chance level lies at 12. According to a binominal test, the probability of having exactly, or more than, 15 hits (K) out of 48 trials (n) is $p = .199$. The receivers' hit rates in the green as compared to the red ganzfeld were not significantly different ($\chi^2 = .814$; $p = .367$). Assessed experiential state variables for the video game and the ganzfeld sessions as well as the measured trait variable absorption did not affect the hit rate. An analysis of participants' responses revealed that independent of the hit rate the four games were identified as targets a strongly unequal number of times. The design of potential future studies is discussed.

Keywords: ganzfeld – VR video games – precognition – altered states of Consciousness – psi

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VR-Videospiel-induzierte Psi-Kommunikation mit rotem und grünem Ganzfeld: Eine Proof-of-Principle-Studie

Zusammenfassung² – In dieser Proof-of-Principle-Studie wollten wir die Ganzfeld-Psi-Methode mit zwei neuartigen Merkmalen anwenden. (1) Wir verwendeten vier verschiedene interaktive Videospiele, die für jeden Durchgang zufällig ausgewählt wurden und vom Sender in einer Virtual-Reality-Umgebung (VR) gespielt wurden, während der Empfänger eine Ganzfeld-Brille trug, die (2) entweder ein rotes oder grünes Ganzfeld erzeugte, zufällig ausgewählt. $N = 48$ junge Paare in einer romantischen Beziehung wurden als Sender-Empfänger-Paare rekrutiert, was 48 Durchgängen entsprach. Im Hinblick auf die Haupthypothese wurden über alle Durchgänge 15 Treffer bei 48 Versuchen registriert, wobei das Zufallsniveau bei 12 liegt. Einem Binomialtest folgend beträgt die Wahrscheinlichkeit, genau oder mehr als 15 Treffer (K) aus 48 Versuchen (n) zu erzielen, $p = .199$. Die Trefferquote der Empfänger im grünen im Vergleich zum roten Ganzfeld waren nicht signifikant unterschiedlich ($\chi^2 = .814$; $p = .367$). Die untersuchten Zustandsvariablen für die Videospiel- und die Ganzfelderfahrungen sowie das gemessene Persönlichkeitsmerkmal Absorption hatten keinen Einfluss auf die Trefferquote. Eine Analyse der Trefferangaben zeigt, dass unabhängig von der tatsächlichen Trefferquote die vier Spiele sehr ungleich oft als Treffer identifiziert wurden. Das Design möglicher zukünftiger Studien wird diskutiert.

Schlüsselbegriffe: Ganzfeld – VR-Videospiele – Präkognition – Veränderte Bewusstseinszustände – Psi

Introduction

The ganzfeld perceptual deprivation procedure has been widely used in parapsychological research for assessing potential anomalous transfer of information, a supposed psi effect. It has been shown that the mere exposure to the ganzfeld leads to altered states of consciousness as participants report vivid imagery and perceive distortions in subjective time as well as regarding somatosensory sensations (Marcusson-Clavertz & Cardeña, 2011; Schmidt et al., 2020; Wackermann et al., 2008). Altered states of consciousness are thought to be psi-conducive and in many studies they have successfully led to psi-related identifications of a stimulus by a *receiver* in the ganzfeld state while a *sender* viewed the stimulus in a separate location (Alvarado, 1998; Bem & Honorton, 1994; Cardeña & Marcusson-Clavertz, 2020; da Silva et al., 2003; Hyman & Honorton, 1986; Roe et al., 2004). The ganzfeld psi procedure consists in a sender-receiver paradigm in which the sender is exposed to a visual stimulus – typically either a photo or a video clip – while the receiver experiences the ganzfeld, a perceptually homogenous

2 Eine erweiterte deutsche Zusammenfassung befindet sich am Ende des Artikels auf den Seiten 320–322.

field of light, typically in red, supplemented by white or brown noise for the auditory channel. Participants are located in separate rooms and are prevented from using any conventional way of information transfer. Following the ganzfeld session, the receiver is presented with four different visual stimuli. One of the four stimuli is the target stimulus which the sender saw during the procedure. The receiver is asked to rank the four stimuli according to similarity with their own visualisation in the ganzfeld. When a sample of subjects in a given study is able to correctly identify the target stimulus significantly above the chance rate of 25% (in case of four stimuli), a psi-effect is assumed (Bem & Honorton, 1994).

The emotional connection between sender and receiver within a couple plays an important role, as significant effects in ganzfeld studies were observed using identical twins (Parker, 2010), friends (Goulding et al., 2004), parent/child pairs, or siblings (Broughton & Alexander, 1997). Due to the possible influence of strong emotional connectedness, we conducted a study with couples who are in a romantic relationship. Anecdotal reports of parapsychological phenomena in everyday life occur especially between two individuals who have a strong emotional relationship. Such cases display what Jung called a *participation mystique*, which in turn can lead to synchronistic phenomena (Schellinger et al., 2019, 2021).

We intended to induce flow states in the sender by using a virtual reality (VR) gaming environment as stimulus material instead of using pictures or video clips which are often not engaging enough. The flow state is defined by deep absorption during challenging activities and by reduced self-awareness and sense of time, as described by Mihaly Csikszentmihalyi (1975). Nine key components of flow are proposed, the first three of which describe objectively measurable dispositions towards the activity, namely a balance between skills and challenges, clear goals, and immediate feedback. Keeping the balance between skills and challenges, while having a clear goal in mind, is proposed to be the main factor in inducing the flow state (Csikszentmihalyi & Csikszentmihalyi, 1992). Inducing flow in a laboratory setting is a challenge, but video games are proven to be effective tools, since they offer tasks with clearly set goals and immediate feedback, and the difficulty of a game can be adjusted to a player's skill level (Khoshnoud et al., 2020). The more people experience flow during video game play, the less attention they pay to time as they engage in the task demands, which is why video gamers who experience deeper states of flow score higher in the game (Rutrecht et al., 2021). Another aspect that speaks in favor of the use of VR video games is the concept of immersion. Although subtle structural differences between flow and involvement/immersion exist (Michailidis et al., 2018), both can be held accountable for inducing a pleasant and absorbed mental state. VR environments are highly immersive because they create a virtual world around an individual, instead of projecting it on a screen. It is also important to note that during video play the sender in the VR environment is an agent and not a passive recipient of a stimulus. Conscious experience in its perceived vitality is highly dependent upon the active interaction of the embodied

agent with their environment. All these characteristics are instrumental to the induction of flow states in the participating sender and to the quality of the signal that should allegedly be received.

As far as the choice of light is concerned, we interchangeably used red and green light for the ganzfeld condition. Our own work (Kübel et al., 2021) has shown that green light sessions, compared to red light sessions, are more relaxing and emotionally positive and have a subjectively shorter duration. We will assess whether the difference in light color makes any difference in terms of stimulus identification.

The Present Study

With the following proof-of-principle study, we intend to use the ganzfeld psi technique with two novel applications. For one, we replaced static photos and video clips with interactive video games played in a VR setting in the laboratory by the sender, while the receiver was lying on a cushioned floor in an electromagnetically shielded EEG cabin. Secondly, the receiver was immersed in either red or green ganzfeld light.

Individual aspects such as the personality of participants have been shown to facilitate psi-effects (Cardeña & Marcusson-Clavertz, 2015). Therefore, the Tellegen Absorption Scale (Tellegen, 1981) was employed to measure the participants' propensity to get absorbed in an activity, an important variable for the induction of altered states of consciousness (Hruby et al., 2024). Following the VR video game and the ganzfeld, both sender and receiver answered questions concerning the states they experienced during the respective session. In particular, the questions revolved around subjective time perception, degree of engagement, valence, and arousal levels, which have shown to be useful indicators when assessing subjective experience in VR gaming (Rutrecht et al., 2021) and in the ganzfeld (Kübel et al., 2021; Müller & Wittmann, 2017).

Methods

Participants

$N = 48$ couples in a romantic relationship, of any gender combination, composed by individuals whose age ranged between 18 and 39 were recruited. We set an age range to assure homogeneity in cognitive abilities and because we thought it would be more likely that people in that age range (as opposed to older people) will have experience with video games. With its $n = 48$ couples, the sample size of our study is comparable to but on the lower end of previous ganzfeld studies utilizing a four-choice design (Bem & Honorton, 1994; Cardeña & Marcusson-Clavertz,

2020; Roe et al., 2004; Storm et al., 2010). Participants were recruited by advertisement on a website of the local university and by word of mouth. Couples demonstrating interest in the study were screened for inclusion criteria through a brief telephone interview of one member of the couple. Exclusion criteria were any psychiatric or neurological disorder. Couples received financial compensation of €30 for taking part in the study session, which lasted approximately 90 minutes. The study was approved by the local Ethics Committee of the Institute for Frontier Areas of Psychology and Mental Health (IGPP, Freiburg, Germany; IGPP_2021_07). All participants provided written informed consent prior to data collection. The study was funded by a grant from the *Society for Psychical Research* to the three authors.

Procedure

Two experimenters (YL, BS) and two participants (the couple) met in a room adjoining an EEG cabin at the institute. At the beginning, after filling out the consent form, participants answered questions related to the Tellegen Absorption Scale and to the duration of their relationship. Then, both sender and receiver were guided through a 10-minute progressive muscle relaxation (PMR) by Jacobson as audio-recorded by one of the experimenters who has extensive experience in guiding PMRs in a research setting (YL). The recording was played to the participants while they were still in the same room. Following the relaxation period, the two experimenters synchronized their watches for the subsequent procedures. The sender was then accompanied by one experimenter to a lab room where the VR video equipment was installed. The two partners were randomly assigned to the two experimenters who overlooked the sessions (VR game / ganzfeld exposure) before their arrival at the institute. The two rooms where the two sessions took place were on the same floor of the building but they were in separate, non-adjacent rooms. The receiver was led into an electromagnetically shielded EEG cabin where he or she was asked to lie down on the floor on comfortable cushions and put on the ganzfeld device. The color of the ganzfeld was assigned before the session by a random number generator (all randomization procedures were done through www.random.org). From that point on, each participant-experimenter pair was separated from the other until the end of the session, so that no unwanted information transfer could happen from the sender that would influence the receiver's decision. To avoid possible interruptions by strangers, the lab door of the sender was clearly marked by red lights and a sign to not disturb, while the room in front of the EEG cabin was occupied by the experimenter, who prevented any unexpected disturbance for the receiver.

For the ganzfeld session, either a green light or a red light was used (randomly selected), combined with brown noise played over earphones. After having introduced the sender to the basic features of the VR device, the experimenter in the sender's room accessed the random number generator via smartphone to randomly generate the number identifying one of the

four games available. Then the sender was given a 5-minute training session to familiarize themselves with the dynamics of the game. The actual game and the ganzfeld session started at the same time, 10 minutes after the sender and receiver had been separated from one another, and lasted exactly 25 minutes. In addition to synchronizing their watches, the experimenters controlled the timing of the sessions by following a planned and precise schedule during their time with their designated participant.

To avoid overwhelming the receiver with what might be considered an impossible task, i. e. to feel what the sender in the other room was experiencing, we provided the following instructions:

In order to get more involved in the situation, we recommend that you first tune in to your partner and make a conscious effort to receive impressions regarding the game. Afterwards, it is helpful to relax and open yourself to everything that may come. Maybe you will feel it intuitively or it is possible that concrete images or emotions will come to you in the ganzfeld, which you will then find to correspond to one of the videos that we will show you afterwards. Some studies successfully showed that people can experience a connection even when they are spatially separated. However, other studies could not find any such effect. Now we would like to conduct our own study on this.

After the simultaneous ganzfeld and VR game sessions were over, the receiver was asked to briefly describe their experience during the ganzfeld in written form. These descriptions were later ranked and evaluated by two independent raters regarding their similarity to the games. Two students who were working as interns in the lab were asked to read all the 48 descriptions and assess, independently from one another, which were compatible with which VR game. After having written down the impression, the receiver was shown 2-minute representative video clips of each of the four games in an alternating order predetermined via a Latin square design. The receiver was then asked to decide which of the four games was the target or came closest to the target and also to rate the three remaining clips (2nd, 3rd, and 4th most likely target). Both sender and receiver answered questions concerning their emotional states of arousal and emotional valence, the passage of time, and their level of engagement in the task during their session (VR game or ganzfeld). After the questionnaires had been filled out, the two experimenter-participant pairs met again in the room adjacent to the EEG cabin, where the experimenter accompanying the sender revealed which game had been played. This disclosure of results at this stage can be interpreted to potentially induce precognitive (retroactive) effects on behalf of the receiver's impression made before during the ganzfeld (Müller et al., 2019; Watt et al., 2020). In experimental settings, precognitive effects have been shown to affect present experience and behavior on time scales from hundreds of milliseconds (Maier et al., 2014; Wittmann et al., 2021) to several days (Müller & Wittmann, 2021), although attempts to repli-

cate specific findings have often failed (Kekecs et al., 2023; Maier et al., 2020), calling for more strictly controlled, preregistered multi-lab studies (Walleczek & von Stillfried, 2019). In order not to influence/overlay the receiver's impressions with knowledge about the four video games, we decided not to switch sender and receiver in a subsequent session. That is, we decided to run only one trial per couple ($n = 48$ couples, $n = 48$ trials).

Measures

Ganzfeld. Participants wore Kasina DeepVision ganzfeld goggles which produce a uniform field of vision through colored LED lights arranged behind a transparent but frosted material. The luminance level can be adjusted manually and was standardized to a light density of ca. 105 cd/m² to 115 cd/m² for both colors assessed through measures with the MAVO-SPOT 2 luminance measuring device (Gossen Foto- und Lichtmesstechnik GmbH). Visual stimulation was controlled by using the Kasina Mind Media System 1.4 (Kasina DeepVision™). The specific sessions were produced through the MIND WorkStation software with RGB values set for red (255-0-0) and green (0-255-0). A fade-in phase of 10 s with increasing brightness was pre-programmed to allow for slow immersion into the colored ganzfeld environment. A fade-out of 30 s from light stimulation to darkness was included to facilitate a pleasant return to the dimmed EEG cabin. Auditory stimuli were transmitted using an MP3 player (AGPTek Longevity Music Player 8 GB) connected to circumaural headphones (Sennheiser HD 201). The applied audio noise was created using Audacity 2.2.1. Participants were exposed to brown noise decreasing with 6 dB per octave with increasing frequency (power density proportional to $1/f^2$). The brown noise was emitted at 50% of the maximum volume of the MP3 player for a comfortable hearing experience.

VR video games. The VR system runs on a Windows 10 PC with an Intel i7-9700K processor; 16 GB RAM; GeForce RTX 2080Ti. The games were played with the Oculus Rift S head mounted display (HMD) with a resolution of 1280×720 pixels. Built-in speakers of the headset reproduced the sound and music of the games. The VR headset's hand controllers were used for interactive behavior in the game. Four different video games (commercially available, Fig. 1a-d) had been selected beforehand to differ from each other in various aspects, namely flow potential, arousal level, agency and control (passive/active), color theme, mode of action control (e.g. hand controller, head or full body movement), and type of challenge. The selection process was supervised by Federico Alvarez Igarzábal, who is a video game scholar. For details on these aspects in the four chosen video games (Beat Saber, Superhot, Eagle Flight, and Explore Fushimi Inari) see Table 1.

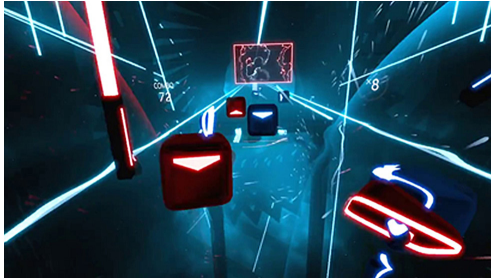
a. *Beat Saber* by Beat Gamesb. *Superhot VR* by Superhot Teamc. *Eagle Flight* by Ubisoft Montreald. *Explore Fushimi Inari* by caves rd

Figure 1a-d. Representative snapshots from the four chosen video games: *Beat Saber*, *Superhot*, *Eagle Flight*, and *Explore Fushimi Inari*

<p>Beat Saber</p> <ul style="list-style-type: none"> • high flow potential • high arousal level • active movements/reaction to stimuli • dark background with neon colors • mainly controller movement, limited • body movement • challenges: timing/rhythm, cognitive processing coupled with hand-eye coordination 	<p>Superhot VR</p> <ul style="list-style-type: none"> • mid-level flow potential • high arousal level • active/high level of control • whitish theme with red opponents and black objects • control by full body tracking, intuitive hand movements • challenges: strategy, awareness and control of full body positioning, 3D awareness of threat and opportunities
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Eagle Flight	Explore Fushimi Inari
<ul style="list-style-type: none"> • high flow potential • low arousal level • passive/lower level of control • natural scenery with tones of brown, gray, green, blue, and orange • head movement plus two buttons • challenges: precise head movement and quick reactions 	<ul style="list-style-type: none"> • low flow potential • low arousal level • active agency/high level of control • green forest scenery with bright red architecture • control via head movement, buttons, and intuitive controller positioning • challenges: none (taking pretty pictures)

Table 1. Contrast criteria for the selection of the four video games regarding the aspects of flow, arousal level, control (passive/active), color theme, mode of action control, and type of challenge.

Ranking of videos by receiver. At the end of the ganzfeld session, the receiver was requested to rank the four presented video clips from 1 to 4, where 1 was the most likely to be the target. The assumed target (rank 1) would then be used as information for confirmatory analysis (25% chance of a hit).

Ranking of videos by two external raters. After the study was completed, two external raters were familiarized with the VR video games, i.e. they played all four games. Then, independently of one another, they read each of the 48 experience descriptions written by the receivers and ranked the four video clips that were presented as reminders from 1 to 4, where 1 was the most likely to be the target.

Trait Absorption. The Tellegen Absorption Scale (Tellegen, 1981), for which a German validated version exists (Ritz & Dahme, 1995), is a 34-item multidimensional measuring tool for imaginative involvement and the tendency to become mentally absorbed in everyday activities. Each item is coded between 0 (no agreement with statement) and 4 (maximum agreement with statement) and their sum score indicates the level of everyday absorption.

State scales. As proxies for experienced flow states during the tasks, visual analogue scales (100 mm) were employed to assess (1) how fast time passed during the session (video game, ganzfeld) and (2) the extent to which the participants could engage in the experience (video game only). As a measure of connectedness, we asked (3) how much the receiver (ganzfeld) was able to engage with the partner (sender) during the session. The Self-Assessment Manikin (SAM; Bradley & Lang, 1994) contains two nonverbal pictorial scales used to assess emotional states of arousal and valence during the session (video game, ganzfeld). We used the 5-point version of the scales. Arousal levels are coded between 0 (minimum) and 4 (maximum). Valence is coded

between -2 (maximum negative affect) and $+2$ (maximum positive affect). We had shown in a previous study that the subjective passage of time and the SAM subscale valence correlated with the experienced flow state (Rutrecht et al., 2021).

Hypotheses and statistics

The confirmatory psi hypothesis H1a is tested against the expected value under the null hypothesis, which is a hit rate of .25 for the rating of $n = 48$ trials. There is a 25% probability that the sender will identify the target stimulus (the actual video game played) by chance only. The observed number of hits for exactly $n = 48$ ratings should be significantly larger than 12 ($K > 12$; binomial distribution) for H1 to be accepted. **The psi hypothesis H1b** refers to the judgment of two independent raters, who were unaware of the receivers' choices and read the 48 descriptions of the ganzfeld experience in order to match each description to one of the video games. For **H1b** the same probabilities apply as in **H1a**.

Several exploratory alternative hypotheses (H_i) will be tested as well.

- H2: The receivers' hit rates in green and red are significantly different according to a χ^2 test.
- H3: Higher trait absorption (TAS) scores for both the sender and receiver will be positively associated with the hit rate, as indicated by a significant positive regression coefficient β .
- H4: Experienced states of the sender in the VR environment are related to the psi effect (significant Spearman correlations with hits $r_s > 0$): (a) valence and arousal levels (SAM), (b) passage of time (VAS), and (c) level of engagement in the VR video game (VAS).
- H5: Experienced states of the receiver in the VR environment are related to the psi effect (significant Spearman correlations with hits $r_s > 0$): (a) valence and arousal levels (SAM), (b) passage of time (VAS), and (c) engagement with the sender as reported by the receiver is related to the psi-effect (significant Spearman correlations with hits $r_s > 0$).

Statistical analyses

The binominal test was calculated to test for the main hypotheses (H1a, b) concerning the statistical significance of a deviation from the theoretically expected distribution of hit rates (the psi effect). This was also done for the red and green conditions separately. Potential differences of hit rates between the two color conditions (H2) were tested with the chi-square (χ^2) statistics. After testing all questionnaire variables for normal distribution using the Kolmogorov–

Smirnov test, it was found that none of the variables was normally distributed. The influence of the trait variable of absorption on the hit rate was determined using a regression analysis with bootstrapping procedures that allows for the use of data that is not normally distributed (H3). For correlation analyses the Spearman coefficient was calculated (H4, H5).

Results

Hypotheses testing

$N = 48$ couples were included in the study. 96% of the participants had completed their secondary education (German Abitur) (sender: $n = 26$, receiver: $n = 30$) or had a university degree (sender: $n = 20$, receiver: $n = 16$). The average age of the participants performing as senders was 24.1 ($SD: 3.4$) and that of the receivers was 24.9 ($SD: 3.5$). The mean duration of the relationship was 2.2 years ($SD: 1.6$; range: 2 months to 7 years and 4 months). As determined by the randomization procedures, 27 women and 21 men were in the ganzfeld (receiver), while 23 women and 25 men performed in the video games (sender). The video games were randomly selected to be played by the senders with the following distribution: Beat Saber: $n = 17$; Superhot: $n = 11$; Eagle Flight: $n = 9$; Fushimi Inari $n = 11$. $N = 27$ receivers had a green ganzfeld light while $N = 21$ had a red ganzfeld light.

Regarding the main confirmatory analysis (hypothesis H1a), where the chance level lies at 12 (25%), 15 hits out of 48 attempts (31.25%) were registered across all trials. According to a binominal test, the probability of exactly, or more than, 15 (K) out of 48 (n) trials is $p = .199$ ($z = .83$). The z -score divided through the square root of $n = 48$ trials corresponds to an effect size (ES) of .12.

Regarding hypothesis H1b, where the chance hit rate would be 12, the two raters both assigned the correct target 10 times out of 48. The probability of exactly, or more than, 10 (K) out of 48 (n) is $p = .795$. The inter-rater Spearman correlation coefficient with $r_s = .326$ is significant ($p = .024$).

The binominal analysis on the receivers' judgments was performed for the green ($n = 27$ trials) and red ($n = 21$ trials) ganzfeld conditions separately. The probability of having exactly, or more than, $K = 7$ hits in $n = 27$ trials in the green condition is $p = .529$. The probability of exactly, or more than, $K = 8$ hits in $n = 21$ trials is $p = .130$. The hypothesis H2 that the receivers' hit rates in green and red are significantly different was disproved by a χ^2 test value of .814 ($df = 1$), which is not significant ($p = .367$).

In testing the influence of the personality trait of absorption (TAS) on the hit rate (H3), a multiple regression analysis for the trait values for sender and receiver, respectively, showed

no significant regression coefficients. Employing a bootstrapping procedure and calculating non-standardized coefficients and the 95% confidence intervals with a lower and upper limit, the parameters for the regression model are as follows: $\beta = -.005$, $[-.002; .013]$, $p = .161$ (sender); $\beta = -.002$, $[-.008; .005]$, $p = .506$ (receiver).

Spearman correlations for the senders' subjective states during the VR video game and the hit rate are not significant. The following correlation coefficients with the hit rate are disclosed: SAM valence: $r_s = -.028$, $p = .849$; SAM arousal: $r_s = -.050$, $p = .737$; passage of time: $r_s = .096$, $p = .517$; level of engagement in the VR video game: $r_s = .055$, $p = .709$.

Spearman correlations for the receivers' subjective states during the VR video game and the hit rate are not significant. The following correlation coefficients with the hit rate were calculated: SAM valence: $r_s = -.048$, $p = .746$; SAM arousal: $r_s = -.083$, $p = .573$; passage of time: $r_s = -.016$, $p = .913$; engagement with the sender: $r_s = .052$, $p = .726$.

Analysis of hits and misses across game types

The number of times each VR game was chosen randomly (16, 11, 10, and 11, respectively) to be played (see Table 2) did not significantly exceed the number of expected values ($n = 12$) according to a one-way χ^2 test ($\chi^2: 1.83$, $df = 3$, $p = .608$). The low number of cases in individual cells in Table 2 (e. g., 1 or 2) violate the assumption of the χ^2 test, so one has to be cautious in interpreting a two-way χ^2 test for differences in the number of hits versus misses across the four games (which would be significant: $\chi^2: 14.7$, $df = 3$, $p = .002$). When *Eagle Flight* was played ($n = 10$) receivers had 8 hits and 2 misses. In contrast, when *Superhot* was played ($n = 11$) individuals had only 1 hit and 10 misses. Similarly, with *Fushimi Inari* ($n = 11$) there were 2 hits and 9 misses.

VR video game	N game played	Hit	Miss
Beat Saber	16	4	12
Superhot	11	1	10
Eagle Flight	10	8	2
Fushimi Inari	11	2	9

Table 2. The number of times each of the VR video games was played by the sender (sum of trials: $n = 48$), the number of hits and number of misses by the receivers separately per game played.

At first sight, *Eagle flight* would seem like the perfect game to induce hits (due to its hit rate of 80%, i. e. 8 hits by the receiver out of the 10 times it was played by the sender). However, an analysis of how often, after each of the 48 trials, the four games were chosen as the target by the receiver (i. e. were identified as rank 1; see Table 3) reveals that *Eagle flight* was chosen 32 times,

followed by *Beat Saber* ($n = 9$), *Fushimi Inari* ($n = 4$), and *Superhot* ($n = 3$). This means that *Eagle flight* induced 24 false positive identifications out of a total of 38 trials in which it was not played (false alarm rate = .632). Calculating d' as a sensitivity index of signal detection theory, with a hit rate of .8 and a false alarm rate of .632, yields a d' of .504, which indicates poor sensitivity (due to the large amount of false positive responses).

VR video game	N rank 1	N rank 2	N rank 3	N rank 4
Beat Saber	9	7	17	15
Superhot	3	9	13	23
Eagle Flight	32	6	6	4
Fushimi Inari	4	26	12	6

Table 3. The number times each of the VR video games was ranked by the receiver in the order of rank 1 to rank 4.

Discussion

To the best of our knowledge this is the first study where the sender of a ganzfeld psi experiment played VR video games. The idea behind this was the intuition that a sender who actively plays a video game is more physically and emotionally engaged than one who just passively looks at a photo or watches a short video clip. VR video games in particular are very absorbing, which increases the chances of inducing states of flow when performing the task (Rutrecht et al., 2021). With a non-significant hit rate of 15 out of 48 trials (31.25%, where the chance score lies at 25%), we could not confirm our main hypothesis. In addition, the two external raters were not able to correctly match the receivers' descriptions to one of the four videos to an extent that can be considered above chance. These null effects occurred although we selected couples who are in a romantic relationship and thus there should be a strong bonding between sender and receiver. It is evident that our experimental setup is no match for the real life-changing or life-threatening situations that have often been associated with parapsychological occurrences (Schellinger et al., 2019, 2021).

Another novelty of our study pertains to the procedure of randomly alternating between the red and green ganzfeld stimulation. Since this is the very first study conducting such a comparison, the achieved null effect of color difference has to be treated with caution, especially since there was no significant overall effect of target hits. This reasoning applies as well to the lack of correlations with all other variables, i. e. subjective states or the personality trait of absorption. We made the assumption that having the senders perform in the flow-inducing VR video games would increase the likelihood of hits by the receivers. This hypothesis was not confirmed and awaits further testing.

A rigorous interpretation of the number of couples in our study leads to the issue of low power. We had a hit rate of 15 out of 48 trials/couples (31.25%). Meta-analyses on four-choice designs show an overall significant hit rate with approximately 30% (63 studies between the years 1992 and 2008; Storm et al., 2010) and 27% (34 studies between the years of 2009 and 2018; Storm & Tressoldi, 2020). That is, our single study with a hit rate of 31% conforms to those overall hit rates which become only significant in meta-analyses, given the large number of studies included. In our single study having 48 trials and a 25% chance rate, we would have had to achieve a hit rate of at least $n = 18$ (37.5%) for it to become significant in the binominal test.

The analyses of hits and misses in relation to false positive responses indicate that the games were picked as the target in an unequal number of times. The VR game *Eagle flight* was assigned as target in two-third (67%) of the cases by the receivers, although that game was played only in 10 out of 48 trials (21%), thus resulting in many false positive responses. In *Eagle flight* the player is an eagle which flies over and down the streets of a post-apocalyptic Paris, which is overgrown with plants and inhabited by animals. The 2-minute video clip of the game shown to the receivers may have provided a higher number of cue types compared to other games, which in turn could have more likely been associated with the variety of impressions the receiver had during the ganzfeld, thus explaining why it was more often identified as the target. The four games were selected by a team of four individuals in order to have qualitative contrasts on several dimensions, namely the flow potential, arousal level, being more passive or active, the color theme, the mode of action control, and the type of challenges the game demands (see Table 1). However, it seems that many of the features that clearly differentiate the games were not relevant for the receivers' perception. Independently of an assumed psi effect, the receivers' were more prone to feeling a correspondence between their own experiences during the ganzfeld with *Eagle flight* as compared to the other three games, which in turn led to such a high number of false positive identifications. To avoid this issue, future studies with VR video games will have to make sure to select games that have a comparable level of appeal for the receivers. That would necessitate empirical studies which contrast the subjective ratings of individuals watching several pre-selected games and then choosing four which were similarly judged. One approach of psi ganzfeld studies is to randomly select four stimuli out of a large set of stimuli, i. e. each subject receives a different set of stimuli drawn from a large repository (e. g., Watt et al., 2020, with $n = 200$ video clips). Since in our case we had to rely on commercially available video games, this would have been too costly. Moreover, such a set up would have substantially increased the size and preparation time of the study, since the researchers would have had to extract 2-minute video clips for each video game and also learn the workings of each of them (in order to properly train the participants). For these reasons, we decided to design this proof-of-principle study like we did, in spite of its limitations, providing a first attempt at using

VR video games in a study of experimental parapsychology. We do not exclude that, with the appropriate resources, such an endeavor with a repository of many VR video games might be undertaken in the future.

Playing VR video games can lead to flow states (Rutrecht et al., 2021) and the ganzfeld is known to induce altered states of consciousness (Schmidt et al., 2022). In addition, we had the sender-receiver couple go through a 10-minute progressive muscle relaxation session; which proved useless in affecting a potential psi effect. Since this psi ganzfeld study employing a VR video game is the first of its kind, further studies with this specific design should be conducted building on our experience. If it is true that altered states of consciousness are psi conducive because they induce losses in the ordinary experiences of self, time, and space (Rabeyron, 2023), other experimental studies could test different types of induction methods, e.g. the intake of psychedelics (Luke, 2012), meditation in experienced meditators (Schmidt et al., 2019), sensory deprivation such as during Floatation-REST (as presently conducted by Kirsty Allan at the University of Northampton), or holotropic breathwork (Rock et al., 2015). Once exploratory experimental studies have been successful, the reliability of their empirical findings will have to be shown in confirmatory replication studies within the context of advanced control techniques (Walleczek & Stillfried, 2019).

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Erweiterte Zusammenfassung

Das Ganzfeld-Verfahren zur Wahrnehmungsdeprivation ist in der parapsychologischen Forschung ein Standardverfahren, um eine mögliche anomale Informationsübertragung, einen vermuteten Psi-Effekt, zu untersuchen. Das Ganzfeld-Psi-Verfahren besteht aus einem Sender-Empfänger-Paradigma, bei dem der *Sender* einem visuellen Stimulus ausgesetzt wird – typischerweise entweder ein Foto oder Videoclip – ,während der *Empfänger* das Ganzfeld erlebt, ein wahrnehmungshomogenes Lichtfeld, typischerweise in Rot, ergänzt durch weißes oder braunes Rauschen für den auditiven Kanal. In vielen Studien konnte gezeigt werden, wie es zu einer Psi-bezogenen Identifikation eines Stimulus durch einen Empfänger im Ganzfeld-kam, während ein Sender den Stimulus an einem räumlich getrennten Ort betrachtete (Alvarado, 1998; Bem & Honorton, 1994; Cardena & Marcusson-Clavertz, 2020; da Silva et al., 2003; Hyman & Honorton, 1986; Roe et al., 2004).

Die emotionale Verbindung zwischen Sender und Empfänger spielt eine wichtige Rolle, da signifikante Effekte in Ganzfeldstudien mit eineiigen Zwillingen (Parker, 2010), Freunden (Goulding et al., 2004), Eltern-Kind-Paaren oder Geschwistern (Broughton & Alexander, 1997) beobachtet wurden. Aufgrund des möglichen Einflusses einer starken emotionalen Verbun-

denheit führten wir deshalb eine Studie mit Paaren durch, die in einer Liebesbeziehung leben. Zudem beabsichtigten wir, Flow-Zustände beim Sender zu bewirken, also leicht veränderte Bewusstseinszustände, indem wir eine Virtual-Reality (VR)-Spielumgebung als Reizmaterial verwendeten – anstatt der üblichen Bilder oder Videoclips. Der Flow-Zustand wird von Mihaly Csikszentmihalyi (1975) durch tiefe Absorption während herausfordernder Aktivitäten und durch eine reduzierte Selbstwahrnehmung und ein verringertes Zeitgefühl beschrieben. Was die Wahl der Lichtfarbe des Ganzfeldes anbelangt, verwendeten wir rotes und grünes Licht, zufällig über die Teilnehmenden verteilt ausgewählt. Unsere eigene Arbeit (Kübel et al., 2021) hat gezeigt, dass Sitzungen mit grünem Licht im Vergleich zu Sitzungen mit rotem Licht spannender und emotional positiver sind und eine subjektiv kürzere Dauer haben.

$N = 48$ junge Paare in einer romantischen Beziehung wurden als Sender-Empfänger-Paare rekrutiert, was 48 Durchgängen entsprach. Wir verwendeten vier verschiedene interaktive Videospiele, die für jeden Durchgang zufällig ausgewählt wurden und vom Sender in einer Virtual-Reality-Umgebung (VR) gespielt wurden, während der Empfänger eine Ganzfeld-Brille trug, die entweder ein rotes oder grünes Ganzfeld erzeugte, was zufällig ausgewählt wurde. Die beiden Partner wurden vor ihrer Ankunft im Institut zufällig den beiden Experimentatoren zugewiesen, die die Sitzungen (VR-Spiel / Ganzfeld) beaufsichtigten. Die beiden Räume, in denen die beiden Sitzungen stattfanden, befanden sich im selben Stockwerk des Gebäudes, aber sie waren in getrennten, nicht benachbarten Räumen. Der Empfänger wurde in eine elektromagnetisch abgeschirmte EEG-Kabine geführt, wo er gebeten wurde, sich auf dem Boden auf bequeme Kissen zu legen und das Ganzfeldgerät anzulegen. Die Farbe des Ganzfelds wurde vor der Sitzung durch einen Zufallszahlengenerator zugewiesen. Von diesem Zeitpunkt an war jedes Teilnehmer-Experimentator-Paar bis zum Ende der Sitzung von den anderen getrennt, so dass keine unerwünschte Informationsübertragung vom Sender auf den Empfänger stattfinden konnte. Am Ende der Ganzfeld-Sitzung, die zeitgleich mit der Videospiele-Sitzung stattfand, wurde der Empfänger gebeten, zu entscheiden, welches der vier Spiele der Sender gespielt hatte (bei vier Videospiele, Wahrscheinlichkeit für einen Zufallstreffer: 25%). Dem Empfänger wurden 2-minütige repräsentative Videoclips von jedem der vier Spiele in einer abwechselnden Reihenfolge gezeigt und er wurde dann gebeten, zu entscheiden, welches der vier Spiele vom Sender gespielt wurde.

Bezogen auf die konfirmatorische Hypothese, bei der das Zufallsniveau bei 12 Treffern (25%) liegt, wurden über alle Durchgänge 15 Treffer bei 48 Versuchen (31,25%) registriert. Nach einem Binomialtest beträgt die Wahrscheinlichkeit von genau oder mehr als 15 (K) von 48 (n) Versuchen $p = .199$. Bei der Unterscheidung zwischen Durchgängen mit rotem und grünem Ganzfeldlicht (grün: $n = 27$ Durchgänge; rot: $n = 21$ Durchgänge) unterschied sich die Trefferquote nicht (für beide Farben ergab sich keine signifikante Trefferquote). Die untersuchten Zustandsvariablen für die Videospiele- und die Ganzfelderfahrungen sowie das gemessene Persönlichkeitsmerkmal Absorption hatten keinen Einfluss auf die Treffer.

Eine detaillierte Analyse unserer Daten im Vergleich mit der Literatur zeigt Folgendes: Wir hatten eine Trefferquote von 15 bei 48 Durchgängen (31,25 %). Meta-Analysen in four-choice-Designs (in Experimenten, bei denen man zwischen vier Optionen auswählen muss) zeigen eine insgesamt signifikante Trefferquote von etwa 30 % (63 Studien zwischen 1992 und 2008; Storm et al., 2010) und 27 % (34 Studien zwischen 2009 und 2018; Storm & Tressoldi, 2020). Das heißt, unsere Einzelstudie mit einer Trefferquote von 31 % entspricht jenen Gesamttrefferquoten, die nur in Meta-Analysen signifikant werden, wenn eine große Anzahl von Studien einbezogen wird. In unserer Einzelstudie mit 48 Durchgängen und einer Zufallsrate von 25 % hätten wir eine Trefferquote von mindestens $n = 18$ (37,5 %) erreichen müssen, damit sie im Binomialtest signifikant wird.

Die Analysen der Treffer und Fehlversuche in Bezug auf falsch-positive Antworten zeigen, dass die Spiele in einer ungleichen Anzahl von Fällen als Ziel ausgewählt wurden. Das VR-Spiel *Eagle flight* (Adlerflug) wurde in zwei Dritteln (67 %) der Fälle von den Empfängern als Ziel ausgewählt, obwohl dieses Spiel nur in 10 von 48 Versuchen (21 %) gespielt wurde, was zu vielen falsch-positiven Antworten führte. Unabhängig von einem vermuteten Psi-Effekt neigten die Empfänger bei *Eagle flight* im Vergleich zu den anderen drei Spielen eher dazu, eine Übereinstimmung zwischen ihren eigenen Erfahrungen während des Ganzfelds und dem Videospiel zu empfinden, was wiederum zu einer so hohen Anzahl falsch-positiver Identifikationen führte. Aufgrund dieser Befunde diskutieren wir das Design möglicher zukünftiger Studien. Soweit wir wissen, ist dies die erste Studie, in der der Sender eines Ganzfeld-Psi-Experiments VR-Videospiele spielt. Da VR-Videospiele fesselnd sind, ist die Wahrscheinlichkeit erhöht, bei der Durchführung der Spiele einen Flow-Zustand zu erzeugen. Wir erhoffen uns, dass aufbauend auf unseren Analysen zukünftige Studien mit verändertem Design positive Ergebnisse zeitigen werden.