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► **To cite this version:**

Burak Erdeniz, Ege Tekgün, Bigna Lenggenhager, Christophe Lopez. Visual perspective, distance, and felt presence of others in dreams. *Consciousness and Cognition*, 2023, 113, 10.1016/j.concog.2023.103547 . hal-04272018

**HAL Id: hal-04272018**

**<https://amu.hal.science/hal-04272018>**

Submitted on 7 Nov 2023

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## **Visual perspective, distance, and felt presence of others in dreams**

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### **Abstract:**

The peripersonal space, that is, the limited space surrounding the body, involves multisensory coding and representation of the self in space. Previous studies have shown that peripersonal space representation and the visual perspective on the environment can be dramatically altered when neurotypical individuals self-identify with a distant avatar (i.e., in virtual reality) or during clinical conditions (i.e., out-of-body experience, heautoscopy, depersonalization). Despite its role in many cognitive/social functions, the perception of peripersonal space in dreams, and its relationship with the perception of other characters (interpersonal distance in dreams), remain largely uncharted. The present study aimed to explore the visuospatial properties of this space, which is likely to underlie self-location as well as self/other distinction in dreams. 530 healthy volunteers answered a web-based questionnaire to measure their dominant visuo-spatial perspective in dreams, the frequency of recall for felt distances between their dream self and other dream characters, and the dreamers' viewing angle of other dream characters. Most participants reported dream experiences from a first-person perspective (1PP) (82%) compared to a third-person perspective (3PP) (18%). Independent of their dream perspective, participants reported that they generally perceived other dream characters in their close space, that is, at distance of either between 0 and 90 cm, or 90–180 cm, than in further spaces (180–270 cm). Regardless of the perspective (1PP or 3PP), both groups also reported more frequently seeing other dream characters from eye level (0° angle of viewing) than from above (30° and 60°) or below eye level (−30° and −60°). Moreover, the intensity of sensory experiences in dreams, as measured by the Bodily Self-Consciousness in Dreams Questionnaire, was higher in individuals who habitually see other dream characters closer to their personal dream self (i.e., within 0–90 cm and 90–180 cm). These preliminary findings offer a new, phenomenological account of space representation in dreams with regards to the felt presence of others. They might provide insights not only to our understanding of how dreams are formed, but also to the type of neurocomputations involved in self/other distinction.

**Keywords:** Dream ; Virtual reality dream theory ; Immersive spatiotemporal hallucination model of dreaming Predictive brain ; Self-model ; Bodily self-consciousness ; Felt presence Distance.

## 1. Introduction

What can dreaming tell us about bodily self-consciousness? According to ‘virtual reality dream theory’ (Hobson & Friston, 2012,2014) and other simulation views of dreaming (Revonsuo, Tuominen, & Valli, 2015; Tuominen, Stenberg, Revonsuo, & Valli, 2019; Windt, 2010), dreams are described as embodied processes of the nervous system in which a model of the self is utilized and integrated into the dream world (see also Limanowski & Blankenburg, 2013; Hopkins, 2016; Bucci & Grasso, 2017). In addition, in many dream experiences, dream self can experience social interactions with other dream bodies, in which these interactions are experienced from a certain distance from the dreamer’s own dream body (Hall & Van De Castle, 1966, Revonsuo, 2006; Revonsuo et al., 2015; Metzinger 2009,2013). In fact, 95% of adults’ dream report showed that an average dream involves up to 4 non-self dream characters (Kahn & Hobson, 2005; see Nielsen & Lara-Carrasco, 2007), experienced as entities distinct from the personal dream self (McNamara, McLaren, Smith, Brown, & Stickgold, 2005, Kahn, Pace-Schott, & Hobson, 2002). Given such findings, one might ask, how is bodily self-consciousness utilized to simulate one’s own and other dream bodies? Moreover, based on knowledge about waking experiences of bodily self-consciousness and peripersonal space (Noel, Blanke, & Serino, 2018; Serino et al., 2018, Serino, 2019), we can also investigate the main features involved in distinguishing between self and other dream bodies and their locations within the dream space (Windt & Metzinger, 2007; Windt, Harkness, & Lenggenhager, 2014). Here, we examined the perspective (first-person perspective, 1PP or third-person perspective, 3PP), viewing angle on and distance to other dream bodies.

Researchers in the field of bodily self-consciousness provide explanatory suggestions for the same kind of questions in waking states (Aspell, Lenggenhager, & Blanke, 2012; Blanke, 2012; Lenggenhager, Lopez, Metzinger, & Windt, 2015) and suggested phenomenological similarities between different pathological conditions experienced during waking and dreaming (i.e., Fregoli syndrome), and the manner in how self and others were sensed in dreams (Irwin, 1986; Schwartz & Maquet, 2002). Moreover, modern virtual reality technology not only made it possible to conduct an experimental investigation of where the self is localized (Lenggenhager, Tadi, Metzinger, & Blanke, 2007), but also opened the way for the investigation of how far one can self-identify with other bodies (Lopez, Falconer, Deroualle, & Mast, 2015; Tekgün & Erdeniz, 2021) and how this process is influenced by different visual perspectives (Ehrsson, 2007; Lenggenhager et al., 2007). A growing body of evidence suggests that our bodily self-consciousness can adopt multiple vantage points depending on states of consciousness during waking (Arzy, Seeck, Ortigue, Spinelli, & Blanke, 2006; Arzy, Thut, Mohr, Michel, & Blanke, 2006). For example, during autoscopic hallucinations, one sees an illusory copy of one’s own body from the location of the physical body with no change in self-identification, self-location or 1PP (Blanke, Landis, Spinelli, & Seeck, 2004), whereas during heautoscopy, one sees alternatively an imaginary body from a 1PP or 3PP (Blondiaux, Heydrich, & Blanke, 2021). Finally, in OBEs, one experiences one’s own self-location and 1PP in the position of the illusory body, which is experienced as looking down on the physical body from an elevated location (Blanke et al., 2004). Here, it is important to note that autoscopic and heautoscopy hallucinations involve a single illusory body belonging to the same person (Brugger, Regard, & Landis, 1997), whereas polyopic forms of autoscopic experiences involve a multitude of bodies (i.e., up to 15 different bodies, Müller, 1826/1967) with different genders and body types (for a review see, Brugger, Blanke, Regard, Bradford, & Landis, 2006). These findings suggest that altered states of bodily self-consciousness show similarities in terms of multiple vantage points adopted during dreaming, and in terms of

phenomenological aspects of self/other distinction in dreams (Kahn, Krippner, & Combs, 2000; see Nielsen & Lara-Carrasco, 2007).

Finally, the feeling of a presence hallucination shows important similarities with dreaming experiences (Windt et al., 2014). During this hallucination, individuals experience (but do not see) a duplicated or secondary body (i.e., usually in the same position as the physical body), which is misperceived as another person (Hara, Blanke, & Kanayama, 2021). Several studies suggested that this hallucination is caused by errors in sensory prediction mechanisms (Bernasconi et al., 2022; Blanke et al., 2014; Garcia et al., 2018), similar to the idea of sensory attenuation (Blakemore, Wolpert, & Frith, 2000; Blakemore, Smith, Steel, Johnstone, & Frith, 2000). In this condition, the sensory consequences of self-generated actions are dampened, and the self is unable to differentiate between the sensory consequences of self-produced action and its predictions, leading to attribution of the physical source to others (Blanke et al., 2014).

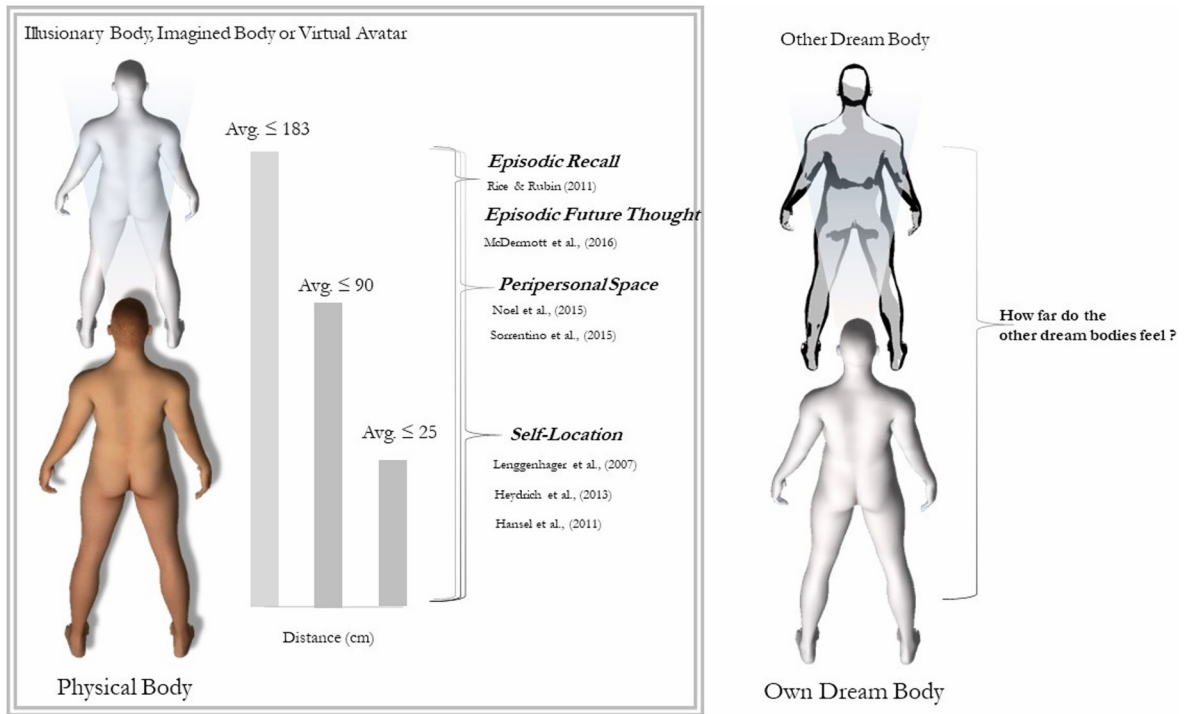
Despite notable differences in the experiential quality of these altered states of consciousness, all show important similarities with the phenomenology of dreaming and provide important insights on the perception of others in dreams (Blackmore, 1987; Windt & Metzinger, 2007; Windt et al., 2014). Various aspects of dreams were investigated in laboratory and home settings (e.g., Rover & Schredl, 2017; emotional states in dreams, Kahn et al., 2002; color in dreams, Hoss, 2010; Schwitzgebel, 2002). However, little is known about the visuo-spatial aspects of dreams (Foulkes & Kerr, 1994; Windt & Metzinger, 2007, Rosen & Sutton, 2013) and their relationship to bodily self-consciousness (Noreika et al., 2020). This is because research on the relation of perspective, distance, and self-identification has focused mainly on waking consciousness. As summarized in Fig. 1, regarding the waking state, several studies examined the felt distances between self and other bodies during episodic memory (Rice & Rubin, 2011), episodic future thoughts (McDermott, Wooldridge, Rice, Berg, & Szpunar, 2016), and experimentally-induced self-identification with fake/virtual bodies (Lenggenhager et al., 2007; Heydrich et al., 2013; Hansel, Lenggenhager, von Kanel, Curatolo, & Blanke, 2011).

The present study is based on the hypothesis of similar neurocomputations carried out during waking and dreaming states (Hobson & Friston, 2012,2014). We argue that during dreaming, similar sensory predictive processes might govern peripersonal space and bodily self-consciousness, which can be determined by the respective reliabilities of different sensory modality experiences during dreaming (i.e., vestibular, visual, somatosensory, etc.). More specifically, the perceived distance and viewing angle of other dream bodies might be determined by computations of sensory predictions similar to that during waking. For example, according to Bayesian predictive framework (Hobson & Friston, 2012,2014; Sohn & Narain, 2021; Yon & Frith, 2021), multisensory neurons coding peripersonal space (i.e., depth-restricted receptive fields) can also be considered as spatial priors (i.e., similar to synchronous sensory stimulation during the rubber hand and full-body illusion experiments) which contributed to bodily self-consciousness (Noel et al., 2018). This suggests that, during dreaming, the strength of embodied sensory experiences and dream peripersonal space may not only determine Bayesian priors (likelihood represented as the uncertainty in sensory data), but also have potential to explain differences in the phenomenology of dream experience (i.e., differences in the location of other dream bodies or changes in dream peripersonal space). In fact, failures in sensory predictive mechanism have been reported for various sensory illusions in awake participants (Moutoussis, Fearon, El-Deredy, Dolan, & Friston, 2014; Chancel, Ehrsson, & Ma, 2022) and might explain symptoms of various psychiatric and neurological disorders (Shergill et al., 2005; Ford & Mathalon, 2005; Schwabe &

Blanke, 2008; Mul et al., 2019; Noel, Cascio, Wallace, & Park, 2017; Randeniya, Oestreich, & Garrido, 2018; Bansal, Ford, & Spering, 2018). During dreaming, similar failures in these predictive processes might also explain differences in self-other location in dreams and might provide a computational account of how dream space works.

It is important to note that we do not aim to compare similarities between neural mechanisms for waking and dreaming experiences. However, we do suggest that, under the predictive reference framework (Clark, 2013; Hohwy, 2013; Bucci & Grasso, 2017), the end product of these computations that involve failed predictions (i.e., sensory attenuation) might show similarities to neuropathological conditions experienced during waking (Bernasconi et al., 2022; Hara et al., 2021; Blanke et al., 2014; Garcia et al., 2018). We put forward the possibility that, an analogous predictive mechanism might also be utilized by the brain during dreaming to the extent of creating a dream bodily self that can lead to the perception of other dream characters at a certain distance and under a certain perspective. Thus, it was argued that computations carried out to form a dream self might involve sensory predictions about the distance of other dream bodies based on its strength of self-identification, and based on different sensory modalities (Erdeniz et al., 2022). If this is true, we could further speculate that the potential outcome that the boundaries of dream space covering social interactions might also be limited by the dream peripersonal space, and the capacity of the dream self to identify with other dream bodies that are typically observed during waking (Blanke & Metzinger, 2009; Makin, Holmes, & Ehrsson, 2008; Salomon et al., 2017).

Firstly, the present study aimed to explore individuals' dominant dream perspective and the frequency of felt distances between the dream self and other dream characters. In addition, we collected reports about the participants' viewing angles of other dream bodies. Secondly, in addition to these exploratory purposes, we devised a family of constituent hypothesis about the relationship between visuospatial aspects of dreams (i.e., perspective, viewing angle and distance to other dream characters) and dream sensations related to sensory modalities, as measured by the Bodily Self-Consciousness in Dreams Questionnaire (Erdeniz et al., 2022). By examining these relationships, we aimed to gain theoretical insight about the internal workings of sensory experiences that occur during dreaming and dream bodily self-consciousness. Consequently, the findings will provide support for the joint hypothesis that there is a positive relationship between visuospatial aspects of dreams and sensory modality experiences during dreaming, and this relationship might resemble predictive processes carried out during various waking states of bodily self-consciousness (Rubin, 2021).



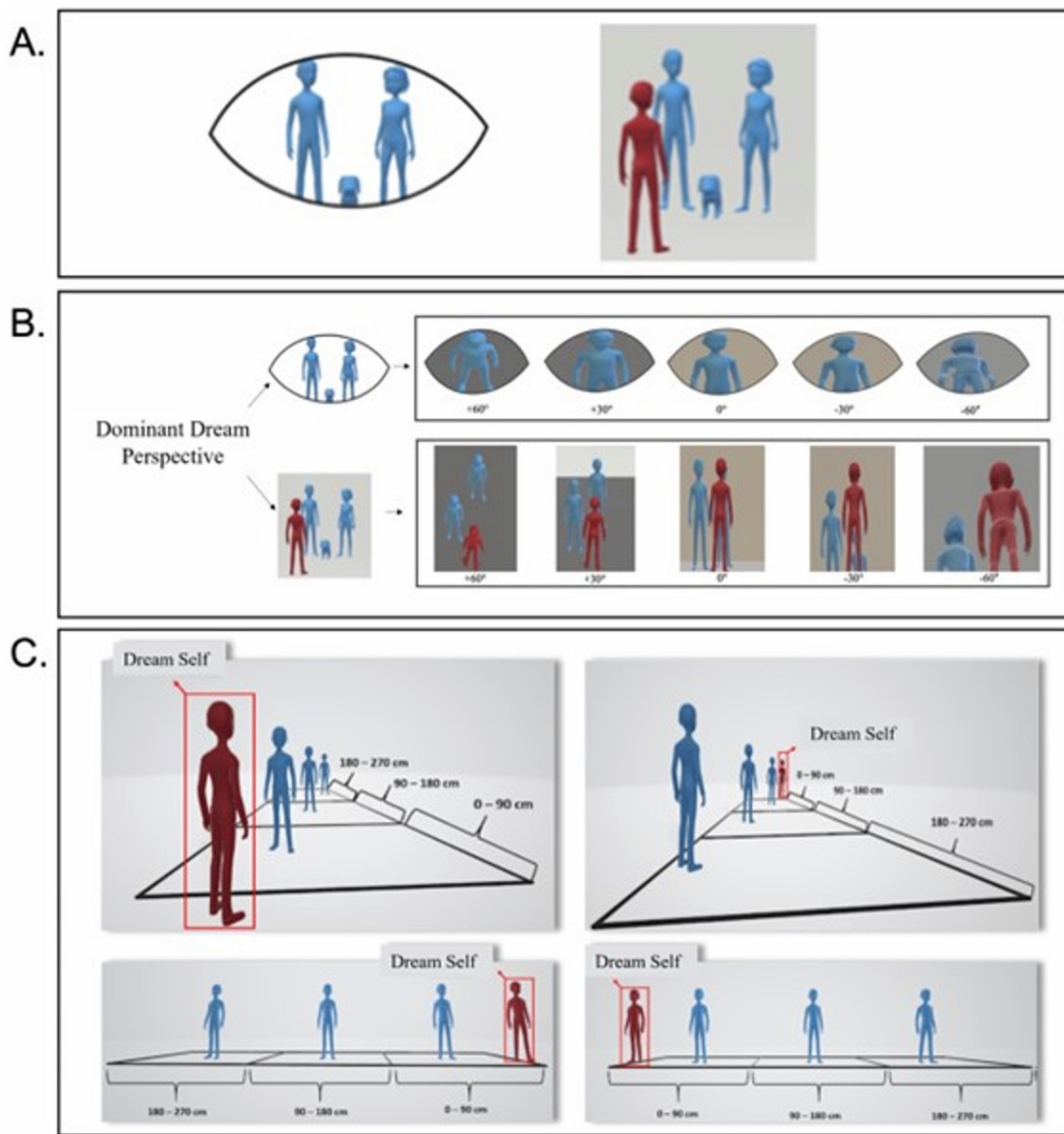
**Fig. 1.** The left side shows remembered and imagined distances between the observer and the other characters during episodic recall, episodic future thought, as well as during experimentally induced changes in peripersonal space boundaries and self-location. The light gray vertical bars represent the average distances between the observer and the other character for remembering and imagery studies, whereas darker gray bars represent the average distances between the physical self and the illusory self for peripersonal space and self-location studies. Data plotted according to Rice and Rubin (2011), McDermott et al. (2016), Noel et al. (2015), Sorrentino et al. (2015), Lenggenhager et al. (2007), Heydrich et al. (2013), and Hansel et al. (2011)”. On the right, the visualization shows the currently unknown representations of perspective, and the extent of variation in the distance and viewing angle between dream self and other dream bodies.

## 2. Materials and method

### 2.1. Participants

In previous dream studies, the dream recall rate during or at the end of rapid eye movement sleep was about 70–80 %, and was only about 50 % for morning or later recalls of dream experiences (Domhoff, 1996). Based on these low recall rates, we decided to collect data from as many participants as possible, and to continue data collection for one month, after which, we stopped, for practical reasons. In the final sample, we were able to collect data from a total of 530 volunteers ( $\mu_{age} = 26.16$  years,  $\sigma_{age} = 9.64$  years, 396 females) online from students, academic and administrative staff at Izmir University of Economics. Data was not analyzed prior to completion of data collection. No participants reported any previous history of any neurological disorder, including sleep-related disorders (i.e., insomnia or narcolepsy). Before the experiment, all participants read a brief description of the study and approved an online informed consent form. The study was approved by the Ethics Committee of the Izmir University of Economics (B.30.2.I·EÜ.0.05.05-020-198).

To confirm that there were a sufficient number of participants, we performed a post-hoc power calculation based on previous perspective-taking tasks. In several perspective-taking tasks, researchers recruited between 60 and 400 participants (Rice & Rubin, 2011; McDermott et al., 2016; Gander & Gander, 2022) and reported a medium effect size (0.3) at the 0.05 alpha level. For the same alpha level and a power of 0.95, we calculated the total sample size using G\*Power 3 software (Faul, Erdfelder, Lang, & Buchner, 2007). The calculation for the chi-square test comparing proportions of 1PP and 3PP revealed that a total sample size of 220 participants was required, and that our study was not underpowered.



**Fig. 2.** (A) Visual cues used to measure dominant perspective in dreams. Participants selected the left image if they more frequently experienced 1PP viewpoint during dreaming, and selected right image, if they more frequently experienced 3PP viewpoint (the red character is identified as the participants personal dream character). (B) Exemplary visual cues used to examine the viewing angle of other dream characters. Depending on the dominant dream perspective, images of 5 different visual angles were presented either from 1PP (top row) or 3PP (bottom row). (C) Illustrations used to cue distance of dream characters in different locations. *Top Panel.* Distance of other dream characters in front of (left scene) and behind (right scene) the dream self. *Bottom Panel.* Distance of other dream characters to the right (left scene) and the left (right scene) of the dream self. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)



## 2.2. Procedures and measurements

All study materials were in Turkish. The online survey was posted to Google Forms between May 24, 2021 and June 8, 2021. After participants approved the online informed consent form, and completed a questionnaire about demographic data (including age, sex, and education level), they were presented with an exploratory questionnaire to characterize the visuo-spatial aspects of dream experiences and with the Bodily Self-Consciousness in Dreams Questionnaire (BSD-Q) (Erdeniz et al., 2022).

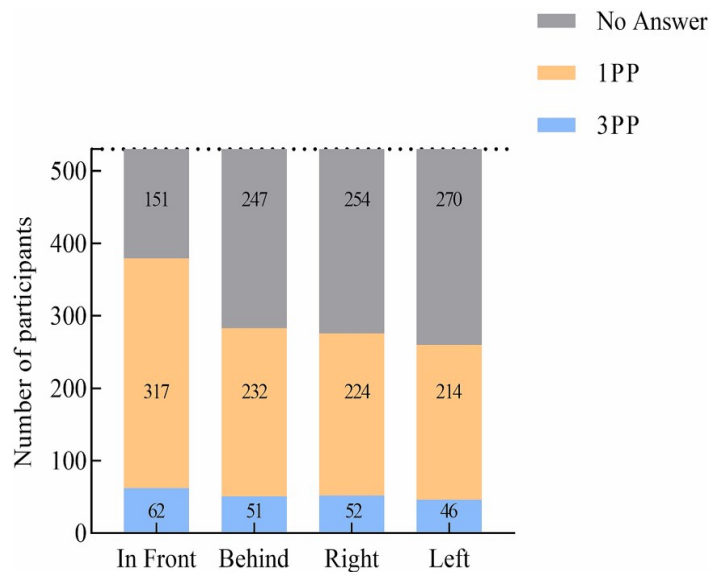
### 2.2.1. Self-reported visuo-spatial dimensions of dreams

We designed a total of 17 exploratory questions about visuo-spatial dimensions of dreams based on previous research in related phenomena of memory and imagery (Rice & Rubin, 2011; McDermott et al., 2016). As in memory and imagery, the representation of self and others can be described by various spatial features. Thus, we divided our questions into 3 sections (i) to identify the dominant visuo-spatial perspective in dreams, (ii) to assess the frequency of angle of viewing other dream characters, and (iii) to assess the frequency of recall of distance between other dream characters relative to the personal dream-self for each location (in front, behind, right and left) (for all items, see Supplementary Material).

Before reading the questions, participants received instructions that the questions had no right or wrong answers. We preferred to restrict recall to the last 3 dreams because there is evidence suggesting that the COVID-19 pandemic had an impact on dreaming (Schredl & Bulkeley, 2020; Walsh, 2020), and at the time, impact of the pandemic was continuing, i.e. we aimed to collect data on dreams prior to the pandemic, but also to avoid dreams in the distant past (in order to increase dream recall accuracy).

*2.2.1.1. Visuo-spatial perspective in the dream.* Participants were cued with pictures with written descriptions of 1PP and 3PP, and asked to choose whether their last 3 dreams were generally experienced from 1PP or 3PP (Fig. 2a). This was a forced choice between 1PP and 3PP, there was no “I don’t remember” option. We used a forced-choice task rather than a Likert scale because it was important to determine the dominant perspective, based on studies showing that individuals are able to recall events from multiple perspectives (Rice & Rubin, 2009) or shift their perspective during recall (Robinson & Swanson, 1993), which might be differentially influenced by psychological factors (i.e., vividness of imagery). The forced-choice task also allowed us to follow up with items about the angle of viewing and distance to other dream characters.

*2.2.1.2. Angle of viewing of other dream characters.* Participants were shown pictures with their descriptions in which dream characters were illustrated from 5 visual angles: from 60° above eye level, 30° above eye level, 0° eye level, 30° below eye level, and 60° below eye level (Fig. 3). Depending on the participants’ response regarding their dominant dream perspective in the previous question, dream characters were shown from a 1PP, or dream characters and the personal dream self were shown from a 3PP. Participants were then asked to rate the mean frequency of seeing other dream characters for each visual angle on a 7-point scale ranging from 1 = never to 7 = always, across the last 3 dreams. Note that for viewing angle questions, there was no “I don’t remember” option.



**Fig. 3.** From left to right, the bars show the total number of participants and their dominant perspective for each spatial location for those able to recall and fill the complete distance questionnaire, from a total of 530 participants (missing values were determined as No Answer).

*2.2.1.3. Location and distance of other dream characters relative to personal dream self.* Participants were shown pictures with their descriptions about the perceived location of other dream characters relative to the personal dream self, reported as one of the following: in front, behind, to the right, or to the left of the personal dream-self (Fig. 2c). For each location, participants were asked to rate how often other dream characters were seen at the following distances: 0–90 cm, 90–180 cm, or 180–270 cm, using a 5-point scale ranging from 1 = never to 5 = always, and from these statistics, we calculated the mean for the last 3 dreams. No visual cues were presented from 1PP because pictures had already been used to guide participants' choice of their dominant perspective for the location and distance items and an "I don't remember" option was included.

### *2.2.2. Bodily self-consciousness in dreams questionnaire (BSD-Q)*

The BSD-Q contains a total of 12 items that measure the intensity of four sensory experiences in past dreams (vestibular, somatosensory, proprioceptive, and visual modalities), which are presented as 4 subscales containing 3 questions each (Erdeniz et al., 2022). Participants rated each item on a 7-point scale ranging from 1 = strongly disagree to 7 = strongly agree. The possible score for the total BDS-Q ranges from 12 to 84, and for each subscale, from 3 to 21. Higher scores indicate stronger sensory experiences in dreams. The descriptive results of the short version of the BSD-Q showed an average score of 49.32 (SD: 4.84) for the total score, and 15 (4.98 SD:), 14.22 (SD: 4.71), 11.97 (SD: 4.71), and 8.19 (SD: 4.35), respectively for the vestibular, somatosensory, proprioceptive, visual subscales (Erdeniz et al., 2022). Finally, a high Cronbach's  $\alpha$  of 0.84 was found for the total score and subscales Cronbach's  $\alpha$  ranges between 0.61 and 0.72.

### 2.3. Data processing and statistical analysis

Because spatial dimensions of dreams are largely under-researched, there are few empirical findings to guide our understanding of the nature of the spatial representation of self and others in dreams. Thus, we analyzed the data by separating into subsets for four locations: in front, behind, right, and left, thus establishing a comprehensive concept of spatial features of others in dreaming. Importantly, for all independent variables, we included an “I don’t remember” option, and those missing values were excluded from the related data group. Statistical analyses were conducted using JASP (Version 0.13). In case of multiple statistical comparisons performed, we applied Benjamini-Hochberg (B-H) procedure (Benjamini & Hochberg, 1995) with a false discovery rate (FDR) rate of 5%. This involved first ranking the p-values for each comparison and then calculating the B-H critical value based on the total number of comparisons performed and the critical FDR value (in our case, 0.05). We accept p-values smaller than the calculated B-H critical value. Finally, after applying this procedure to all multiple comparisons, significance for both corrected (B-H critical value reported as  $\alpha_{b-h}$ ) and uncorrected p-values (reported as  $p$ ) were reported. The data is available for download from Mendeley (<https://data.mendeley.com/datasets/5vgg5yty4j/draft?a=a19fd283-b8bc-403e-9597-ba68066e515f>).

## 3. Results

### 3.1. Perspective

The overall data from 530 participants revealed that 82% of participants chose 1PP as their dominant perspective in dreams, whereas only 18% chose 3PP. A chi-square test of goodness-of-fit (expected values = 50%) confirmed that these proportions were not uniformly distributed,  $\chi^2(1, N = 530) = 218.11, p < .001$ , such that, 1PP was more commonly adopted. Subsequent analyses indicated no relationship between dominant dream perspectives and demographic variables. The dominant perspective was not significantly related to the participant’s sex (chi-square test of independence:  $\chi^2(1, N = 530) = 0.07, p = .79$ ) and age (point-biserial correlation:  $r_{pb} = -0.009, n = 530, p = .838$ ).

### 3.2. Relationship between perspective and location

First, we investigated whether the distribution between 1PP and 3PP in dreams varied across the factors of seeing other dream characters in the front, behind, right side or left side of one’s dream self. Separate chi-square tests were performed to examine the frequency of perspectives along each location. A certain trend toward significance was shown for 1PP in front,  $\chi^2(1, N = 530) = 3.027, p = .08$  (uncorrected for multiple comparison), but not for other locations: back,  $\chi^2(1, N = 530) = 0.004, p = .95$ ; right,  $\chi^2(1, N = 530) = 0.328, p = .567$ ; left,  $\chi^2(1, N = 530) = 0.019, p = .89$ . However, the p-values for all these comparisons (including 1PP in front) were insignificant after applying the Benjamini-Hochberg procedure (critical B-H values for front,  $\alpha_{b-h} = 0.0125$ ; back,  $\alpha_{b-h} = 0.05$ ; right,  $\alpha_{b-h} = 0.025$ ; left  $\alpha_{b-h} = 0.0375$ ), indicating no significant difference in the distribution of visual perspective among different locations (see Benjamini, Drai, Elmer, Kafkafi, & Golani, 2001 for a discussion on FDR correction for chi-square tests).

A follow up logistic regression analysis was performed to ascertain the effect of the perceived location of other dream characters relative to the personal dream self on the likelihood that participants report a dominant 1PP or 3PP. The model was not found to be statistically significant,  $\chi^2(4, N = 530) = 5.373, p = .251$ , and explained between 1% (Cox & Snell  $R^2$ ) and 1.7% (Nagelkerke

$R^2$ ) of the variance in the dominant perspective and correctly classified 82% of the cases. The results of the model showed that only remembering dream characters in front significantly predicted the odds of participants' dream perspective,  $X^2(1) = 4.304, p = .038$ . That is, remembering other dream characters in this position (in front) was associated with an increase in the likelihood of having 1PP as the dominant dream perspective (OR = 1.786, 95%CI [0.032, 1.128]). However, there was no significant contribution to the model of remembering other dream characters behind ( $X^2(1) = 0.62, p = .43, OR = 0.798, 95\%CI [-0.787, 0.335]$ ), right ( $X^2(1) = 1.571, p = .21, OR = 0.646, 95\%CI [-1.119, 0.246]$ ), and left ( $X^2(1) = 0.638, p = .424, OR = 1.337, 95\%CI [-0.422, 1.002]$ ). After applying the Benjamini-Hochberg procedure (critical B-H values for front,  $\alpha_{b-h} = 0.0125$ ; back,  $\alpha_{b-h} = 0.05$ ; right,  $\alpha_{b-h} = 0.025$ ; left  $\alpha_{b-h} = 0.0375$ ), indicating no significant predictive relationship between visual perspective and location of seeing other dream characters in different locations.

### 3.3. Relationship between perspective and visual angles

Out of 530 participants only 356 reported that they accurately remembered the viewing angle of other dream characters, and only those participants who recalled all five angles were included in the following analysis. We ran a  $2 \times 5$  mixed ANOVA with perspective (1PP, 3PP) as a between-subject factor and visual angle (from 60° above eye level, 30° above eye level, eye level 0°, 30° below eye level, 60° below eye level) as a within-subject factor. Mauchly's test indicated a violation of the sphericity assumption,  $X^2(9) = 213.15, p < .001$ , therefore Huyn-Feldt corrected results are reported ( $\epsilon = 0.79$ ). The results revealed a significant main effect for visual angle,  $F(3.20, 1133.53) = 180.19, p < .001, \eta^2 = 0.34$ , but not for perspective,  $F(1, 354) = 1.04, p < .309$ . Importantly, a significant interaction between visual angle  $\times$  perspective was found,  $F(3.20, 1133.53) = 4.26, p = .004, \eta^2 = 0.01$  (Fig. 4). After applying the B-H procedure for FDR correction, the main effect of visual angle ( $\alpha_{b-h} = 0.0167$ ) and the interaction between visual angle  $\times$  perspective remained significant ( $\alpha_{b-h} = 0.033$ ), but the main effect of perspective ( $\alpha_{b-h} = 0.05$ ) (for the B-H procedure for ANOVA see, Cramer et al., 2016). Simple main effect analysis showed that participants with dominant 1PP dream perspective reported seeing other dream characters from eye level (0° degree angle) significantly more frequently compared to those with dominant 3PP ( $p = .003$ ).

### 3.4. Relationship between perspective and distance

To examine the relationship between dominant perspectives in dream and felt distance of other dream characters in the front, behind, right, and left of the dream body, we ran 4 separate  $2 \times 3$  mixed ANOVA with perspective (1PP, 3PP) as a between-subject factor and felt distance (0–90 cm, 90–180 cm, and 180–270 cm) as a within-subject factor (separate analyses were performed due to missing values per location due to large difference in the total number of participants in each category). Mauchly's test indicated a violation of the sphericity assumption for each spatial category (front:  $X^2(2) = 72.3, p < .001$ ; behind:  $X^2(2) = 121.27, p < .001$ ; right-side:  $X^2(2) = 97.79, p < .001$ ; left-side:  $X^2(2) = 89.64, p < .001$ ). Therefore, for the front ( $\epsilon = 0.85$ ), right-side ( $\epsilon = 0.77$ ) and left-side ( $\epsilon = 0.77$ ) categories, Huyn-Feldt corrected p values were reported, while Greenhouse-Geisser corrected p values were reported for the behind category ( $\epsilon = 0.74$ ). Furthermore, previous studies showed that exploratory mixed ANOVAs inherently contain multiple comparisons problem, and B-H method is one of the remedies for this (Cramer et al., 2016). Therefore, we also applied Benjamini-Hochberg procedure to each ANOVA analysis and report significance based on B-H critical values (in total we compared 8 separate main effects and

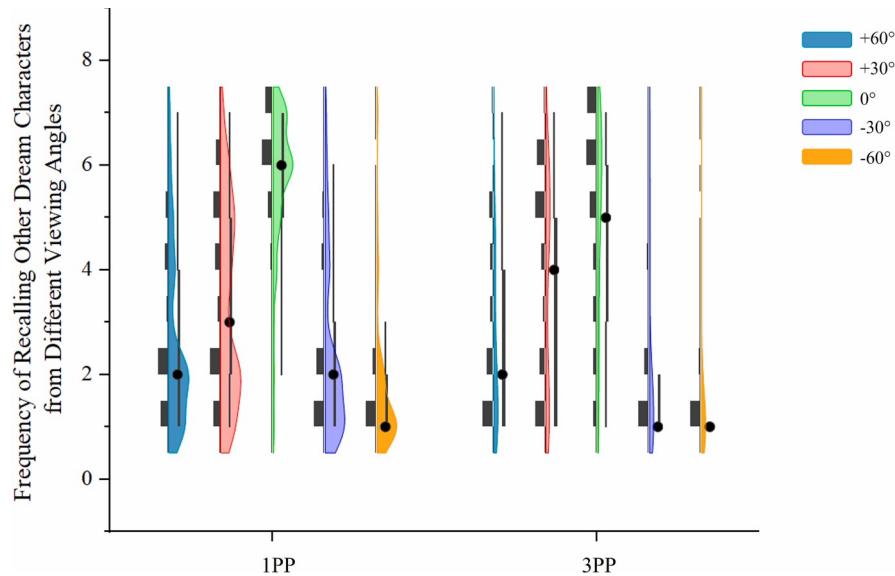
4 separate interactions). In addition to that, Bonferroni adjustment was applied for all post-hoc comparisons. Fig. 5 illustrates the frequency of recall for each distance interval.

The front category ratings showed a significant main effect of distance on the frequency of recall for other dream characters,  $F(1.71, 642.42) = 140.21, p < .001, \eta^2 = 0.16$ . The p value for the main effect of distance was significant ( $\alpha_{b-h} = 0.004$ ) after applying the B-H procedure. Post-hoc comparisons revealed that the mean scores for 0–90 cm ( $M = 3.89, SD = 0.96$ ), 90–180 cm ( $M = 3.01, SD = 1.01$ ), and 180–270 cm ( $M = 2.39, SD = 1.10$ ) were significantly different from each other (all  $t \geq 6.27, p_{bonf} < 0.001$ ). There was no main effect of perspective,  $F(1,376) = 0.08, p = .772$ , and no significant interaction,  $F(1.71, 642.42) = 0.497, p = .579$ . The findings for the main effect of perspective and interaction remained insignificant after evaluating their p value against adjusted alpha (Main effect of perspective,  $\alpha_{b-h} = 0.008$ , Interaction effect,  $\alpha_{b-h} = 0.0125$ ).

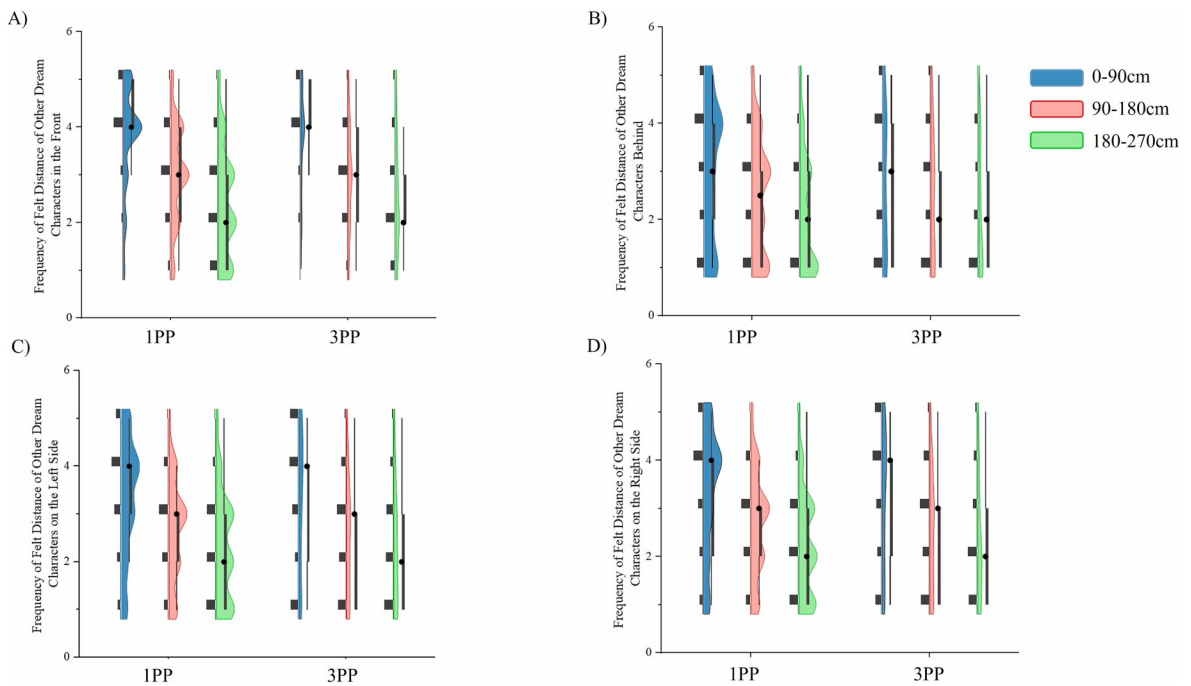
The behind category ratings revealed a significant main effect of distance on the frequency of recall for other dream characters,  $F(1.48, 415.83) = 28.06, p < .001, \eta^2 = 0.03$ . The p value for the main effect of distance was significant ( $\alpha_{b-h} = 0.016$ ) after applying the B-H procedure. Post-hoc comparisons revealed that the mean scores for 0–90 cm ( $M = 2.93, SD = 1.41$ ), 90–180 cm ( $M = 2.42, SD = 1.17$ ), and 180–270 cm ( $M = 2.11, SD = 1.16$ ) were significantly different from each other (all  $t \geq 3.202, p_{bonf} < 0.004$ ). There was no main effect of perspective,  $F(1,281) = 0.14, p = .70$ , or interaction,  $F(1.48, 415.83) = 1.79, p = .18$ . The findings for the main effect of perspective and interaction remained insignificant after evaluating their p value against adjusted alpha (main effect of perspective,  $\alpha_{b-h} = 0.0208$ , Interaction effect,  $\alpha_{b-h} = 0.025$ ).

The right-side category ratings revealed a significant main effect of distance on the frequency of recall for other dream characters,  $F(1.54, 421.27) = 65.44, p < .001, \eta^2 = 0.19$ . The p value for the main effect of distance was significant ( $\alpha_{b-h} = 0.029$ ) after applying the B-H procedure. Post-hoc comparisons revealed that the mean scores for 0–90 cm ( $M = 3.31, SD = 1.31$ ), 90–180 cm ( $M = 2.61, SD = 1.08$ ), and 180–270 cm ( $M = 2.20, SD = 1.05$ ) were significantly different from each other (all  $t \geq 3.636, p_{bonf} < 0.001$ ). There was no significant main effect of perspective,  $F(1,273) = 0.24, p = .62$ , or interaction,  $F(1.54, 421.27) = 0.82, p = .42$ . The findings for the main effect of perspective and interaction remained insignificant after evaluating their p value against adjusted alpha (main effect of perspective,  $\alpha_{b-h} = 0.033$ , Interaction effect,  $\alpha_{b-h} = 0.375$ ).

The left-side category ratings revealed a significant main effect of distance on the frequency of recall for other dream characters,  $F(1.55, 396.88) = 62.39, p < .001, \eta^2 = 0.07$ . The p value for the main effect of distance was significant ( $\alpha_{b-h} = 0.041$ ) after applying the B-H procedure. Post-hoc comparisons revealed that the mean scores for 0–90 cm ( $M = 3.32, SD = 1.28$ ), 90–180 cm ( $M = 2.61, SD = 1.08$ ), and 180–270 cm ( $M = 2.25, SD = 1.09$ ) were significantly different from each other (all  $t \geq 3.230, p_{bonf} < 0.004$ ). There was no significant main effect of perspective,  $F(1,256) = 0.27, p = .60$ , or interaction,  $F(1.55, 396.88) = 0.43, p = .60$ . The findings for the main effect of perspective and interaction remained insignificant after evaluating their p value against adjusted alpha (Main effect of perspective,  $\alpha_{b-h} = 0.045$ , Interaction effect,  $\alpha_{b-h} = 0.05$ ).



**Fig. 4.** Frequency of recalling other dream characters shown for a 7-point Likert scale for each viewing angle were presented for two dominant visual perspective (1PP and 3PP). Half violin plot with bin bars on the left shows a kernel density estimate of the full distributions for the frequency of recalling other dream characters from different viewing angles; +60°, +30°, 0°, - 30°, - 60°. The width of the shaded area representing the proportion of the data located per each condition. Medians are indicated by black circles. Boxes indicate the quartiles with whiskers reaching up to 1.5 times the interquartile range.



**Fig. 5.** Frequency of recalling other dream characters shown for a 5-point Likert scale for each distance interval were presented for two dominant visual perspective (1PP and 3PP). Half violin plots with bin bars on the left show a kernel density estimate of the full distributions for the recalling frequency of other dream characters at different locations: (A) Front, (B) Behind, (C) Left, (D) Right. Medians are indicated by black circles. Boxes indicate the quartiles with whiskers reaching up to 1.5 times the interquartile range.

### 3.5. Correlations between the BSD-Q scores and perspective

Firstly, we determined the descriptive statistics of the BSD-Q (Table 1). Next, we calculated a point-biserial correlation to determine whether there was an association between sensory experiences during dreams and dreaming from a 1PP or 3PP. There was no significant correlation between total BSD-Q scores and dominant dream perspective ( $r_{pb} = -0.005$ ,  $N = 530$ ,  $p = .901$ ). Further, logistic regression was performed to ascertain the effect of BSD-Q subscales on the likelihood that participants report 1PP or 3PP as a dominant dream perspective. The model was not found to be statistically significant,  $X^2(4, N = 530) = 8.87$ ,  $p = .06$ . The model explained between 1.7% (Cox & Snell  $R^2$ ) and 2.7% (Nagelkerke  $R^2$ ) of the variance in the dominant perspective and correctly classified 82% of the cases. Only the visual subscale significantly predicted the odds of dominant dream perspective,  $X^2(1) = 4.96$ ,  $p = .026$ . Specifically, greater intensity of visual experiences during dreams was associated with an increased likelihood of having 1PP as the dominant dream perspective (OR = 0.939, 95%CI [- 0.118, - 0.008]). The results of the model showed that no significant information was added by the vestibular subscale ( $X^2(1) = 2.65$ ,  $p = .103$ , OR = 1.049, 95%CI [- 0.10, 0.105]), somatosensory subscale ( $X^2(1) = 0.68$ ,  $p = .407$ , OR = 1.026, 95%CI [- 0.036, 0.088]), or proprioceptive subscale ( $X^2(1) = 0.22$ ,  $p = .639$ , OR = 0.987, 95%CI [- 0.070, 0.043]). After applying the Benjamini-Hochberg procedure, all modalities became insignificant (critical B-H values for visual,  $\alpha_{b-h} = 0.0125$ ), vestibular,  $\alpha_{b-h} = 0.025$ ; somatosensory,  $\alpha_{b-h} = 0.0375$ ; proprioceptive  $\alpha_{b-h} = 0.05$ ). The results indicate no significant predictive relationship between dominant dream perspective and bodily self-consciousness scores.

### 3.6. Predictive relationship between BSD-Q subscales and visual angles

In order to test whether subscales of BSD-Q predicted the angle of view of dream characters, multiple linear regression analyses were conducted separately (considering five independent regression analysis) for each viewing angle. Additional FDR correction was applied separately for each analysis (4 comparison for each visual angle).

For viewing from 60° above eye level, the regression analysis indicated that the model explained 2.2% of the variance,  $F(4, 403) = 2.247$ ,  $p = .063$ , adjusted  $R^2 = 0.012$ . The regression models  $p$  value remained insignificant after applying the B-H procedure ( $\alpha_{b-h} = 0.05$ ). The analysis showed that visual modality significantly contributed to the model ( $\beta = -0.04$ ,  $p = .039$  uncorrected), but there was no such contribution from the vestibular ( $\beta = 0.034$ ,  $p = .092$ ), somatosensory ( $\beta = -0.03$ ,  $p = .182$ ) and proprioceptive ( $\beta = -0.024$ ,  $p = .214$ ) modalities. However, after applying the Benjamini-Hochberg procedure, the contribution of all modalities became insignificant (critical B-H values for visual,  $\alpha_{b-h} = 0.0125$ ; vestibular,  $\alpha_{b-h} = 0.025$ ; somatosensory,  $\alpha_{b-h} = 0.0375$ ; proprioceptive  $\alpha_{b-h} = 0.05$ ). For viewing angle from 30° above eye level, the regression analysis indicated that the model explained 3.4% of the variance,  $F(4, 426) = 3.786$ ,  $p = .005$ , adjusted  $R^2 = 0.025$ . The  $p$  value remained significant after applying the B-H procedure ( $\alpha_{b-h} = 0.04$ ). It was found that vestibular ( $\beta = 0.044$ ,  $p = .054$ ), somatosensory ( $\beta = -0.014$ ,  $p = .584$ ), visual ( $\beta = 0.031$ ,  $p = .149$ ), and proprioceptive ( $\beta = -0.027$ ,  $p = .211$ ) modalities did not significantly predict 30° viewing angle. After applying the Benjamini-Hochberg procedure, the contribution of all modalities remained insignificant (critical B-H values for visual,  $\alpha_{b-h} = 0.025$ ; vestibular,  $\alpha_{b-h} = 0.0125$ ; somatosensory,  $\alpha_{b-h} = 0.0375$ ; proprioceptive  $\alpha_{b-h} = 0.05$ ).

For viewing angle from eye level 0°, the regression analysis indicated that the model explained 5.4% of the variance,  $F(4, 487) = 6.899$ ,  $p < .001$ , adjusted  $R^2 = 0.046$ . The  $p$  value remained

significant after applying the B-H procedure ( $\alpha_{b-h} = 0.01$ ). The analysis showed that only somatosensory modality ( $\beta = 0.066, p < .001$ ) significantly contributed to the model at eye level. There was no significant contribution from vestibular ( $\beta = 0.007, p = .671$ ), visual ( $\beta = -0.026, p = .093$ ) and proprioceptive ( $\beta = 0.023, p = .132$ ) modalities. After applying the Benjamini-Hochberg procedure, with the exception of the contribution of somatosensory modality (critical B-H values for somatosensory,  $\alpha_{b-h} = 0.0125$ ), all modalities remained insignificant (visual,  $\alpha_{b-h} = 0.025$ ; vestibular,  $\alpha_{b-h} = 0.05$ ; proprioceptive  $\alpha_{b-h} = 0.0375$ ).

For viewing from  $-30^\circ$  below eye level, the regression analysis indicated that the model explained 4.7% of the variance,  $F(4,436) = 5.340, p < .001$ , adjusted  $R^2 = 0.038$ . The p value remained significant after applying the B-H procedure ( $\alpha_{b-h} = 0.02$ ). The analysis showed that somatosensory ( $\beta = -0.055, p = .011$ ) and visual ( $\beta = 0.073, p < .001$ ) modalities significantly contributed to the model, but not vestibular ( $\beta = 0.011, p = .583$ ) and proprioceptive ( $\beta = -0.013, p = .471$ ) modalities. After applying the Benjamini-Hochberg procedure, with the exception of the contribution of visual (critical B-H values for visual,  $\alpha_{b-h} = 0.0125$ ) and somatosensory modality (critical B-H values for somatosensory,  $\alpha_{b-h} = 0.025$ ), all modalities were insignificant (vestibular,  $\alpha_{b-h} = 0.0375$ ; proprioceptive  $\alpha_{b-h} = 0.05$ ).

Finally, for viewing angle from  $-60$  below eye level, the results of the regression indicated the model explained 4.1% of the variance,  $F(4,436) = 4.625, p = .001$ , adjusted  $R^2 = 0.032$ . The p value remained significant after applying the B-H procedure ( $\alpha_{b-h} = 0.03$ ). The analysis showed significant contributions to the model from somatosensory ( $\beta = -0.040, p = .038$ ), visual ( $\beta = -0.050, p = .003$ ), and proprioceptive ( $\beta = -0.037, p = .027$ ) modalities, but no contribution from vestibular modality ( $\beta = -0.010, p = .565$ ).

After applying the Benjamini-Hochberg procedure, only visual modality remained significant (critical B-H values for visual,  $\alpha_{b-h} = 0.0125$ ), and the other three modalities became insignificant (critical B-H values for somatosensory,  $\alpha_{b-h} = 0.0375$ , vestibular,  $\alpha_{b-h} = 0.05$ , proprioceptive  $\alpha_{b-h} = 0.025$ ).

**Table 1**

Descriptive statistics for scores of total and subscales of BSD-Q ( $N = 530$ ).

BSD_Q	<i>M</i>	<i>SD</i>	Min; Max
Total BSD-Q	51.36	13.93	12; 84
Vestibular subscale	14.91	4.69	3; 21
Somatosensory subscale	16.02	4.34	3; 21
Proprioceptive subscale	11.85	5.03	3; 21
Visual subscale	8.58	4.68	3; 21

Note: Min = Minimum; Max = Maximum.



### 3.7. Predictive relationship between the total BSD-Q scores and the average self-reported visuo-spatial dimensions of dreams

Finally, in order to evaluate the relationship between total BSD-Q score and the distances at which other dream characters are more frequently seen (0–90 cm, 90–180 cm, 180–270 cm), separate multiple linear regression analyses were carried out for each spatial location (four independent tests including each location: in front, behind, right-side, left-side).

For the front category, the results of the regression indicated that the model explained 8.4% of the variance and was a significant predictor of total BSD-Q scores,  $F(3,374) = 11.50$ ,  $p < .001$ , adjusted  $R^2 = 0.077$ . The p value remained significant after applying the B-H procedure ( $\alpha_{b-h} = 0.0375$ ). The distances of 0–90 cm ( $\beta = 1.99$ ,  $p = 0.006$ ) and 90–180 cm ( $\beta = 2.50$ ,  $p = 0.002$ ) contributed significantly to the model, while the distance of 180–270 cm did not ( $\beta = 1.09$ ,  $p = 0.14$ ). After applying the Benjamini-Hochberg procedure, the contribution of the 0–90 cm and 90–180 cm distances remained significant (critical B-H values for 0–90 cm,  $\alpha_{b-h} = 0.016$ ; 90–180 cm,  $\alpha_{b-h} = 0.03$ ) but that of the 180–270 cm distance became insignificant (critical B-H values for 180–270 cm,  $\alpha_{b-h} = 0.05$ ).

For the behind category, the results of the regression indicated that the model explained 9.7% of the variance in total BSD-Q scores,  $F(3,279) = 9.97$ ,  $p < .001$ , adjusted  $R^2 = 0.087$ . The p value remained significant after applying the B-H procedure ( $\alpha_{b-h} = 0.05$ ). The model showed that the distance of 90–180 cm ( $\beta = 2.39$ ,  $p = 0.04$ ) contributed significantly to the model, unlike the distances of 0–90 cm ( $\beta = 1.036$ ,  $p = 0.17$ ) and 180–270 cm ( $\beta = 0.70$ ,  $p = 0.48$ ). After applying the Benjamini-Hochberg procedure, the contribution of all distances became insignificant (critical B-H values for 0–90 cm,  $\alpha_{b-h} = 0.016$ ; 90–180 cm,  $\alpha_{b-h} = 0.03$ , 180–270 cm,  $\alpha_{b-h} = 0.05$ ).

For the right-side category, the results of the regression indicated that the model explained 13.2% of the variance in total BSD-Q scores,  $F(3,271) = 13.70$ ,  $p < .001$ , adjusted  $R^2 = 0.122$ . The p value remained significant after applying the B-H procedure ( $\alpha_{b-h} = 0.025$ ). The model showed that the distance of 0–90 cm ( $\beta = 2.89$ ,  $p < 0.001$ ) significantly predicted the total BSD-Q scores, whereas the distances of 90–180 cm ( $\beta = 0.89$ ,  $p = 0.42$ ) and 180–270 cm ( $\beta = 1.09$ ,  $p = 0.26$ ) did not contribute the model. After applying the Benjamini-Hochberg procedure, the contribution of 0–90 cm distance remained significant (critical B-H values for 0–90 cm,  $\alpha_{b-h} = 0.016$ ), but the other distance intervals were insignificant (critical B-H values for 90–180 cm,  $\alpha_{b-h} = 0.05$ , 180–270 cm,  $\alpha_{b-h} = 0.03$ ).

For the left-side category, the results of the regression indicated that the model explained 18.5% of the variance, and was a significant predictor of total BSD-Q scores,  $F(3,254) = 19.25$ ,  $p < .001$ , adjusted  $R^2 = 0.176$ . The p value remained significant after applying the B-H procedure ( $\alpha_{b-h} = 0.0125$ ). While the distances of 0–90 cm ( $\beta = 2.58$ ,  $p < .001$ ) and 90–180 cm ( $\beta = 2.52$ ,  $p = 0.03$ ) contributed significantly to the model, the distance of 180–270 cm did not ( $\beta = 0.95$ ,  $p = 0.34$ ). After applying the Benjamini-Hochberg procedure, the contribution of 0–90 cm distance and 90–180 cm distance intervals remained significant (critical B-H values for 0–90 cm,  $\alpha_{b-h} = 0.016$ ; 90–180 cm,  $\alpha_{b-h} = 0.033$ ), but the 180–270 cm distance interval was insignificant (critical B-H values for 180–270 cm,  $\alpha_{b-h} = 0.05$ ).

Taken together, the results indicated that participants who reported more frequently seeing other dream characters at distances of either 0–90 cm or 90–180 cm tended to report higher levels of sensory experiences in dreams provide support for our main joint hypothesis (indicated by the predictive relationship between total BSD-Q scores and average self-reported visuo-spatial dimensions of dreams) as measured by separate regression analysis for each location.

## 4. Discussion

The current study aimed to explore the visuo-spatial aspects of dreaming. Participants were first asked about the most frequent visual perspective in their last 3 dreams. Results showed that 1PP was significantly more frequently adopted than 3PP in dreams. Participants also reported that eye level was the most frequent position from which other dream bodies were seen, in line with findings from memory research (Rice & Rubin, 2011), showing that for 1PP and 3PP participants, most frequently see other dream bodies from an eye level (0° degree). Participants also rated the frequency of how often they see other dream bodies from the three distances in each of the four directions (front, behind, right, and left). Results showed that other dream characters were less frequently represented from the distance of 180–270 cm than from 0 to 90 cm and 90–180 cm, irrespective of the reported perspective and location. Finally, multiple regression analyses showed that the stronger the sensory experience in dreams, the closer other dream bodies are seen in relation to the self-dream body. These findings raise questions in relation to perspective, self-other distinction, and peripersonal space in dreams, all of which are discussed below.

### 4.1. Perspective in dreams

During waking, our perception of the world and our body is accessible from two different perspectives: 1PP and 3PP (Vogeley & Fink, 2003). From a 1PP, observations of objects and processes are available internally to the observer's mind (direct epistemic access) through the senses (Chalmers, 1999). The 3PP requires the mental simulation of a viewpoint or perspective outside the physical body (indirect epistemic access) (Nagel, 1974; Choifer, 2018). At the cognitive level, the 1PP uses an egocentric reference frame, originating from the body, and 3PP, an allocentric reference frame, localized outside the body, in space (Vogeley & Fink, 2003). Many studies in the field of spatial cognition investigated these phenomena using perspective-taking tasks which involve mentally adopting others' perspective (van Elk & Blanke, 2014; Vogeley et al., 2004). As a result, perspective-taking was considered a crucial component of bodily self-consciousness that enables self-other distinction (Ruby & Decety, 2003; David et al., 2006; Petkova, Khoshnevis, & Ehrsson, 2011; Blanke, Slater, & Serino, 2015).

Similar to waking states, philosophical approaches also suggested that in most dreams, the dream self can experience its environment either from a 1PP (i.e., actor or own-eyes, field view) or a 3PP (i.e., observer view) (Kahan & LaBerge, 1996; Revonsuo, 2005; Rosen & Sutton, 2013). Previous studies suggested that a 1PP dream experience might very much resemble a typical waking experience from an embodied perspective, where a dreamer perceives only what is visible from the dream body's viewpoint, whereas a 3PP dream might be experienced similar to an out-of-body experience (Blackmore, 1982; Levitan, LaBerge, DeGracia, & Zimbardo, 1999; Bergouignan, Nyberg, & Ehrsson, 2022). Aside from these speculations, according to our knowledge, the only study that directly investigated the visual perspective in dreams in a systematic fashion (by using EEG and waking participants immediately after REM sleep) reported that participants adopted only 1PP during REM sleep (Foulkes & Kerr, 1994). However, that study included only 4 participants, motivating us to investigate the same question with a much larger sample size.

Our exploratory findings confirmed philosophical discussions and suggested the possibility of adopting both 1PP and 3PP perspectives in dreams, with dreams more frequently experienced from a 1PP perspective. The results showed that there is no significant interaction between the distance of seeing other dream characters in different locations and the dominant perspective in dreams

(1PP or 3PP), but we found a significant interaction between the visual angle of seeing other dream characters and the dominant dream perspective. Additionally, our findings also showed that neither BSD-Q scores nor the location of seeing other dream characters in different locations significantly predicted the dominant dream perspective. Based on those findings, it is important to further elaborate on which aspects of dream experiences might be better than others in predicting the dominant perspective. In order to do that, we first need to understand how participants were even able to report seeing others behind them from a 1PP. A solution suggested by several dream theorists is that the self in dreams does not necessarily need to include a body image, and it can experience the feelings of other dream bodies through sensory modalities other than visual (i.e., felt movement) (Occhionero & Cicogna, 2011). For example, during waking, in the absence of visual information, individuals could feel or sense someone standing behind them in a line and might predict the distance between them. A similar process may occur in dreams. Strauch and Meier found that in about 71% of dream reports, participants experience a dream self, whereas the others reported that the dream self was absent or inactive (1996, pp.114–5). This finding suggests that dream experiences that correspond to weakly embodied sensory processes do not necessarily require a dream body image (Occhionero & Cicogna, 2011). Thus, visual perspective in dreaming might not be experienced in the same fashion as during waking (see also examples of blind individuals who experience perspective differently, Kennedy & Juricevic, 2006). Domhoff (1996), in a very large sample of participants, found that the phenomenon of seeing part of one's own body (e.g., head, extremity, torso or anatomy) in dreams was reported by only 10% of males and 12% of females. Based on this finding, we propose two alternative explanations. Firstly, during dreaming, participants might be simultaneously utilizing multiple sensory experiences (i.e., visual and somatosensory) leading to fused sensory experience not easily separable into different sensory components (i.e., through Bayesian causal inference, Shams & Beierholm, 2022). In such a scenario, individuals might feel the presence of another dream body somatosensorily at their back, but might nevertheless, misleadingly report this as a visual event (failure to predict sensory cause during multisensory integration), similar to an illusory shadow person (Arzy, Seeck, et al., 2006) or a feeling of a presence (Blanke et al., 2014; Bernasconi et al., 2022). Second, there might be very rapid transitions between 1PP and 3PP, for example, in the form of altercentric intrusions (Samson, Apperly, Braithwaite, Andrews, & Bodley Scott, 2010), or even the possibility of experiencing different perspectives simultaneously (Rice & Rubin, 2009; Furlanetto, Bertone, & Becchio, 2013). Thus, an important goal for further studies will be to understand which of these two propositions better explains perspective differences in dreams.

Another important point to highlight is that both 1PP and 3PP viewers reported seeing other dream bodies from eye level. This finding is very similar to that observed by Rice and Rubin (2011) in their autobiographical memory study. We can speculate that participants may use their own physical body height while simulating other dream bodies during dreaming or autobiographical recall. However, due to the lack of specific data in the current study (e.g., heights of the individual participants), follow-up investigations are required.

Our findings are also in line with previous memory studies which showed that both 1PP and 3PP were utilized during the recall of memories, with better recall for 1PP compared to 3PP memories (Nigro & Neisser, 1983; Rice & Rubin, 2011; McDermott et al., 2016). These earlier studies suggested that visual perspective not only contributes to memory formation for events, but also shapes the nature of subjective experience that forms the self (Rubin & Umanath, 2015; Prebble, Addis, & Tippett, 2013). As memory research showed that distant memories are more likely to be

experienced from 3PP than 1PP (Frank & Gilovich, 1989; Nigro & Neisser, 1983; Piolino et al., 2006; Piolino et al., 2007; Robinson & Swanson, 1993; Pronin & Ross, 2006; Brewer & Pani, 1996; Sutin & Robins, 2008; Viard et al., 2007), the larger frequency of 1PP dreams reported in the present study may be related to the instructions to focus on the last three dreams, rather than, for example, childhood dreams. Furthermore, several studies highlighted the role of 3PP memories serving a distancing or continuity function, depending on the motivational state of the observer (Libby & Eibach, 2002, Libby, Eibach, & Gilovich, 2005). For example, individuals are more likely to remember events from a 3PP when the particular aim is to highlight their current or past selves (Libby et al., 2005). This suggests that motivational status also has a significant influence on recalling the perspective. Future research should investigate carefully the perspective in dreams in relation to the stage of life in which the dreams occurred (i.e., childhood vs. adulthood), and the motivational status of the participant at the time of their dream.

#### 4.2. *Self/other location and peripersonal space in dreams*

‘Where do we localize ourselves in space?’ is an important question regarding bodily self-consciousness (Blanke, 2012). Previous studies highlighted the relationship between perspective-taking and self-location (Serino et al., 2013; Blanke et al., 2015). For example, a few studies showed that self-location is linked to the experienced direction of 1PP (Pfeiffer et al., 2013; Maselli & Slater, 2013), whereas others highlighted the importance of the relationship between visual perspective and spatial congruency of the participant’s physical body (Guterstam, Bjornsdotter, Gentile, & Ehrsson, 2015; Pavlidou, Gallagher, Lopez, & Ferr’e, 2019). Regarding these questions, people can localize themselves in a place other than their physical body during out-of-body experiences (De Ridder, Van Laere, Dupont, Menovsky, & Van de Heyning, 2007), or may experience themselves in two rapidly alternating locations during heautoscopy (Brugger et al., 1997; Blanke et al., 2004).

Several studies also showed that self-location can be utilized as a reference point for building peripersonal representations, that is, the area around the body that is accessible or vulnerable to outside items or people (Rizzolatti, Fadiga, Fogassi, & Gallese, 1997; Brozzoli, Gentile, & Ehrsson, 2012; Serino, 2019; Noel, Bertoni, & Serino, 2021). Noel, Pfeiffer, Blanke, and Serino (2015) showed that when the boundaries of peripersonal space extended towards the virtual body with which participants self-identified, the perceived self-location was closer to the virtual body. Thus, it was argued that peripersonal space not only allows interaction with others (de Haan, Smit, Van der Stigchel, & Dijkerman, 2016), but also makes possible self-other distinctions (Pellencin, Paladino, Herbelin, & Serino, 2018). These studies suggested that peripersonal space is sensitive to the social context, and that it is involved in coding the interpersonal distance (the relative distance between people during interaction), based on the availability of sensory information during social interactions (Rabellino, Frewen, McKinnon, & Lanius, 2020; Coello & Cartaud, 2021). For instance, Iachini, Coello, Frassinetti, and Ruggiero (2014) showed that interacting with human-like stimuli reduces interpersonal distance compared to non-human-like stimuli (Teneggi, Canzoneri, di Pellegrino, & Serino, 2013). Hence, it was argued that the predictive mechanism used to estimate the interpersonal distance not only facilitates calculation of the location of others, but also utilizes the distance information in relation to the boundaries of the peripersonal space (Brozzoli et al., 2012; De Vignemont, 2018).

As a consequence, under the influence of such findings, we propose that multisensory neurons and neural predictive mechanisms contributing to peripersonal space and self-location in awake

participants might also be involved in dreaming (see also, Szymanek, 2021; Simor, Bogdany, & Peigneux, 2022). This requires the brain to generate sensory predictions about non-self dream bodies, which may also include predictions of interpersonal distances. However, a more complex aspect of dreaming is examining the relationship between the location of own and others' dream body which requires more than simply recalling the perspective or location. This problem is exacerbated by the lack of a direct metric to measure psychological distance in dreams. Here, we only found that individuals with greater intensity of sensory experiences during dreaming experienced other dream characters at shorter distances. Under these circumstances, we can only highlight the results of the current study, particularly the distance relationship between own dream body and other dream bodies, and their resemblance to the findings of studies reporting a feeling of a presence and associated illusory changes in self-location.

## 5. Limitations and future work

There are several limitations to our approach. Firstly, a previous study argued that dreams are minimal perceptual environments because they are perceived as dark spaces (Levitan et al., 1999). Accordingly, it is impossible to perceive visuospatial depth and indicate distance in dreams that are devoid of any visual content. Although this view contrasts our initial premise (the verb "to see" used in the questionnaire was deliberately chosen), it was possible to report distances regardless of visual sensation, but this might be experienced as felt presences of others (Brugger et al., 1997). This possibility emerges from the suggestion in some studies that a dreamer might have the potential to make observations by utilizing modalities other than visual (Leslie & Ogilvie, 1996, Erdeniz et al., 2022). In this case, future studies should include participants reporting specific aspects of the dream content regarding sensory modality.

Another potential limitation is that 1PP perspective memories are generally remembered better than those from the 3PP perspective (Rice & Rubin, 2009; Akhtar, Justice, Loveday, & Conway, 2017; Marcotti & St. Jacques, 2018). This may account for the fact that, in the current study, certain conditions have up to almost 50% missing values; i.e., a possible reason for the greater proportion of 1PP dreams is that they are more likely to be remembered. Currently, the best solution to overcome this drawback in future studies would be to wake the participants during or at the end of rapid eye movement sleep and administer the dream questionnaire (see for example, Noreika et al., 2020). Moreover, future studies should link the questionnaire data with the content of dream reports (i.e., written accounts of dreams), which will help to identify different spatial and temporal components, as well as highlight emotions accompanying dreams (i.e., positive/negative emotions might influence the distance or angle to other dream characters).

Finally, it is important to note that although the current study might suffer from the same methodological limitations generally associated with online questionnaires (i.e., self-selection bias, false respondents) (Menon, & Muraleedharan, 2020; Levi, Ridberg, Akers, & Seligman, 2022), the results are consistent with laboratory experiments (Rice & Rubin, 2011; Christian, Miles, Parkinson, & Macrae, 2013; McDermott et al., 2016; Gander & Gander, 2022) and an online study that we conducted earlier (Erdeniz et al., 2022).

## 6. Conclusion

The current study is an initial attempt to explore how different characteristics of waking bodily self-consciousness (i.e., perspective and self-location) are represented in individuals' dream space. Our results provide evidence for the involvement of different perspectives in dreams, and are

compatible with previous studies on experience of dreaming (Chauhan, Cole, Berthoz, & Sarlegna, 2022; Simor et al., 2022), and experience when awake, specifically those involving peripersonal space (e.g., Noel et al., 2015), perspective-taking (Rice & Rubin, 2009) and memory (Rice & Rubin, 2011). In conclusion, the findings of the present study provide important theoretical insight for developing further studies on other core components of bodily self-consciousness (body-ownership and sense of agency) during dreaming.

### **Conflict of Interest Statement.**

The authors whose names are listed immediately below certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

### ***CRediT authorship contribution statement***

**Burak Erdeniz:** Conceptualization, Supervision, Methodology, Data curation, Writing – original draft. **Ege Tekgün:** Methodology, Data curation, Formal analysis, Writing – original draft, Visualization. **Bigna Lenggenhager:** Writing – review & editing, Validation. **Christophe Lopez:** Writing – review & editing, Validation.

### **Declaration of Competing Interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### **Data availability**

I have shared the link to raw data.

### **Acknowledgements**

We would like to thank our undergraduate research assistants Melisa Ceren Çimili, Baha Utkun Düşkün, Nida Meto and Gülsah Şak for helping us during the data collection.

### **Appendix A. Supplementary material**

Supplementary data to this article can be found online at:  
<https://doi.org/10.1016/j.concog.2023.103547>.

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