Virtual Reality: Characteristics and application in anxiety disorders and other clinical settings

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Abstract

Virtual Reality (VR) technology places users in a computer-generated three-dimensional environment, where they experience a variety of visual and auditory cues related to their clinical needs. Despite the considerable growth of scientific knowledge in this field, its application to clinical practice has been slow. The aim of this article is to synthesise the evidence on the application of virtual reality exposure therapy (VRET) interventions in the treatment of various disorders: eating disorders, psychotic disorders, and addictions, focusing on anxiety disorders, in adults and in developmental age. VR technologies make it possible to create and replicate dangerous and impossible situations in the real world, enabling the precise acquisition of data, facilitating a more careful evaluation of rehabilitation progress. furthermore, by exploiting the characteristics of immersiveness and presence, it is possible to virtually recreate the perfect clinical setting for each intervention.

Keywords: virtual reality, anxiety, therapy, clinical, adolescents, exposure

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Introduction

Virtual reality (VR) is a computer-generated simulation of the three-dimensional environment with which one can interact in a realistic way. It is an immersive technology that projects the user to any location using a special device, allowing the replication of situations that are difficult to experience (Schultheis & Rizzo, 2001).

It is composed of experiential and technological factors that can determine a radical change in the subject's self-experience. This experience is possible through advanced human-machine interaction, which exploits sensory input devices. In this way, the user interacts with the digital environment, which can be a digital simulation of reality or depart from it completely.

The word "virtual" denotes something that "is in power and not in act". It may seem similar to the concept of "imaginary" or "mental", with the difference that virtual worlds can be shared between multiple individuals (Bombari *et al.*, 2015; De Jong *et al.*, 2013). Indeed, multiple people can meet in a virtual room and experience through the senses, but not as much can be done in an imaginary room.

At the beginning, VR was predominantly dominated by the sense of sight through wearable viewers. Today, through new and interesting technologies, VR allows its users to provide increasingly multimodal feedback including touch (gloves and body armour), hearing, and proprioception through tracking body movement and posture. All these technologies make it possible to enhance the process of embodiment (embodiment) of the user in the virtual body (avatar) and immerse or transfer them within the virtual environment so they can interact with it (Grabarczyk & Pokropski, 2016).

The aim of this study is to provide the reader with a general overview of the main features and possibilities of virtual reality exposure therapy (VRET)'s use in psychology. The authors performed a literature search on three main databases: PubMed, Web of Science and Scopus.

The concept of immersivity

One of the main characteristics of virtual experience is related to the concept of immersivity, which can be described as a deep state of physical involvement in the medium, such as in a book, a movie, or a virtual environment (Bombari *et al.*, 2015; de Jong *et al.*, 2013). In virtual space, this sense of immersion is influenced by factors such as the use of a digital alter ego of the physical self, an avatar, and aspects related to the type of technology used (Slater & Steed, 2000). The main purpose of using an avatar is to be an extension of the subject's personality. In fact, the more customizable it is, the greater the user's involvement in the experience. The ability to interact with environments and objects also fosters a sense of presence and action (Waltemate *et al.*, 2018). There are also aspects related to technology that enable greater user involvement by promoting the experience, for example, the extension of the field of view, the possibility of using different sensory systems (haptic, visual, auditory), the realism of the image and virtual environment, or even the tracking of the user's movement. Augmenting the experience of a sensorimotor contingency allows the simulated sensory data to match the subject's proprioception (Sanchez-Vives & Slater, 2005).

The concept of presence

The higher the user involvement, the greater the sense of presence. The user feels that they exist in the virtual environment, as if they have the sensation of being embodied in the avatar (embodiment) (Grabarczyk & Pokropski, 2016; Sanchez-Vives & Slater, 2005; Slater & Sanchez-Vives, 2014; Waltemate *et al.*, 2018). The sensation of embodiment is enabled by the spatial coincidence and multisensory correlation between the virtual and real bodies, creating an overlap between the two (Slater, 2009). Subjects who experience an environment in VR feel that they occupy a precise body space (self-location), that they can cause or generate effects with that body (self-agency), and that that precise body is the seat of the sensations felt (body ownership), all of which led to perceiving the lived experience as real and plausible. What the virtual experience allows is a sense of self-

identification by subjects in the virtual body that can temporarily lead to a change in behaviour and self-image. Neurobiologically, through studies of "mirror neurons", it has been shown that similar brain regions are activated both when we observe a body state and when we experience it ourselves, again creating an overlap between us and that body state. The same effect occurs with the virtual avatar (Keysers & Gazzola, 2009).

The concept of self-agency

The last element that characterizes the virtual experience is related to the concept of self-agency or sense of agency. Our bodies are endowed with perceptual and motor functions that allow us to contact our surroundings. We can control our actions and predict their consequences in a continuous interaction between individual and environment (Gallagher, 2000). This reciprocity is also possible in virtual environments, where new technologies allow tactile feedback. Technologies make the movement and perception of the subject in space increasingly realistic and current. Some studies have shown how this effect is greater when the avatar is controlled synchronously and has elements of resemblance to one's physical body, going to increase the sense of immersion and presence experienced (Kokkinara *et al.*, 2015; Ma & Hommel, 2015; Nahab *et al.*, 2011; Tieri *et al.*, 2015).

Virtual reality in the treatment of anxiety disorders

The advent of virtual reality, based on the reconstruction of immersive virtual scenarios, is receiving great attention as a branch of research. Responding and meeting the demand for interventions in the mental health field is the health care challenge of recent decades (Kessler *et al.,* 2001), and modern technologies represent the tipping point for bridging some practical limitations and meeting the demands for support and assistance. The use of technological tools, in fact, may represent an evolution in several clinical conditions, especially in the treatment of anxiety disorders. In fact, psychotherapy is one of the most interesting and promising areas of Virtual Reality application.

The VRET has become an important therapeutic tool for mimicking relevant social situations within a therapeutic setting and has been shown to have the potential to elicit patients' social distress (Kampmann *et al.*, 2016). Anxiety-related disorders are the most prevalent class of mental disorders, especially considering the effects of the pandemic (35.1% in the general population) (Huang & Zhao, 2020). NICE guidelines (2013) suggest selective serotonin inhibitor drug therapy (SSRI) and cognitive behavioural oriented psychotherapy (CBT) as elective treatments in anxiety disorders. CBT is based on the use of experiential, in vivo or imaginal exposure techniques that expose the subject to the feared situation or object. In this way, the exposure is intended to correct the individual's dysfunctional beliefs about his or her ability to cope with the feared stimulus and to reduce its threat. Exposure-based therapies are indicated for the treatment of obsessive-compulsive disorders (OCD), post-traumatic stress disorder (PTSD), panic disorder (PD), specific phobias, and social anxiety disorder (SAD; APA Presidential Task Force on Evidence-Based Practice, 2006), however, some exposures may sometimes be impractical. VRET is proving to be a viable alternative, useful in overcoming possible structural limitations (Fernandez & Riva, 2020). VR represents a perfect tool to foster experiential learning; the therapist exploits the simulation power of VR, which can induce emotional responses (Vincelli *et al.*, 2001; Vincelli & Riva, 2007) with the advantage of being in a protected environment (Wilson & Soranzo, 2015). Virtual reality (VR) technology offers a unique opportunity to spread exposure therapy. The technology is improving so that the image quality is better, and the cost is much lower than traditional psychotherapy (Miloff *et al.*, 2016).

One study showing that 76 percent of participants chose VRET over in vivo exposure (Garcia-Palacios *et al.,* 2007). Its effectiveness comes from its applicability to different everyday life situations *(*Morina *et al.*, 2015), the possibility of personalizing the multisensory content of stimuli capable of eliciting emotional states of fear (Loucks *et al.*, 2019), remaining within the therapist's office. The use of a virtual environment allows, in addition, greater control of environmental variables by the therapist, who can modulate the form and frequency of stimuli (Scozzari & Gamberini, 2011) according to exposure hierarchies agreed with the patient. The participant responds to relevant

stimuli while immersed in a larger virtual environment that can be controlled, differing from traditional experimental settings, where relevant stimuli can be controlled but the surrounding environment often cannot. Rizzo *et al.* (1999) describe virtual environments as "the ultimate Skinner box," capable of presenting a range of complex stimulus conditions that would not be easily controlled in the real world and allowing examination of both cognitive (e.g., attention) and search processes (Rizzo *et al.*, 2004).

A recent meta-analysis (Carl *et al.*, 2019) reported improved anxiety symptoms and reduced anxiety crises following VRET use. In the study, repeated virtual and gradual exposure to feared stimuli led to changes in cognition, behaviours, and emotional and physical responses. Exposure facilitates the extinction of the fear response. It helps to modify dysfunctional evaluations of threat, reducing the conditioned anxiety associated with feared stimuli (Abramowitz, 2013; Foa & Kozak, 1986). Gradual exposure allows habituation and reassessment of threat. Extensive research demonstrates the effectiveness of treatment in phobias (Abramowitz *et al.*, 2011; Ougrin, 2011). Meta-analysis (Carl *et al.*, 2019) supports the use of VR for social anxiety disorder, performance anxiety, and panic disorders. VRET has also been used in several additional areas of anxiety from stress management (Pallavicini *et al.*, 2016; Shah *et al.*, 2015) to generalized anxiety disorders (Repetto *et al.*, 2013).

Process variables in anxiety outcomes

A few variables that might influence the effects of virtual reality exposure therapy in anxiety outcomes were analysed. A central process aspect affecting treatment outcome is the therapeutic alliance between therapist and client. Because of its modest but stable ability to predict treatment outcome, therapeutic alliance has become one of the most studied process variables in research. One study (Meyerbröker *et al.*, 2008) investigated the mediating role of the therapeutic alliance in 14 patients with fear of flying. The purpose of the study was to test if the quality of the therapeutic alliance could predict successful outcomes in VRET. The results showed a positive correlation between therapeutic alliance and treatment outcomes as reduction of anxiety

symptoms. Similarly, Ngai and colleagues (2015) reports a positive association between the anxiety reduction and therapeutic alliance, as observed in studies using face-to-face interventions. The results overcome the controversy arising from the lack of eye contact due to technological devices (helmet) (Meyerbröker *et al.*, 2008; Wrzesien *et al.*, 2015).

Morina *et al.* (2014) notes how virtual reproduction of social interactions through VRET can activate in individuals both symptoms of anxiety and the sense of presence, understood as "being inside" the virtual context, characteristic of in vivo interactions. However, the study shows how the sense of presence is not an indicator of the onset of anxiety symptoms (Morina *et al.*, 2014). Moreover, the subject might experience the virtual environment as unrealistic, resulting in a low sense of presence, but still experience anxiety symptoms due to the presence of the therapist as a source of negative judgment especially in subjects with social anxiety (Morina *et al.*, 2014). Therefore, contrary to most hypotheses, the sense of presence is a necessary but not determinant condition in the effectiveness of intervention with VRET. Similarly, more empirical evidence is needed (Fernandez *et al.*, 2020). It is assumed that there might be differences between adults and children in the level of engagement within the experience elicited by virtual reality (Bercea, 2021).

Some evidence also suggests that in addition to therapeutic alliance, patients' positive expectation of outcome also plays a role in improving the outcome of interventions in VRET. Prince and colleagues (2008) shows that higher positive expectancy toward treatment in VRET led to greater symptom reduction in self-report measures.

Outcome in adults with social anxiety

Most studies show that VRET in subjects with anxiety disorders, including social anxiety, is superior to the control group under waitlist or psychological placebo conditions, with results fairly comparable to those with in vivo exposure (Carl *et al.*, 2019), even in drop-out levels (Anderson *et al.*, 2013; Benbow *et al.*, 2019; Fodor *et al.*, 2018). Parsons and Rizzo (2008) evaluated the effectiveness of VRET in social anxiety disorder reporting a decrease in symptoms; however, the

lack of a control group limits the evaluation of its effectiveness. The review by Powers *et al.* (2008) also found comparable results, obviating the limitations of the previous study. Based on the available results, there are no significant differences at post-intervention between in vivo and VR protocols; however, the efficacy of VRET may decrease in the long term (Anderson *et al.*, 2013).

VRET in adolescent with social anxiety

Social anxiety is among the most common mental disorders and is characterized by an excessive concern about being exposed to the negative judgment of others in specific social and performance situations. The individual is frightened by the possibility that others may notice the characteristic manifestations of the neurophysiological arousal of anxiety (APA, 2013). This results in impairment in daily and relational functioning, such as difficulties in school, limited or absent social relationships (Maes *et al.*, 2019; Vilaplana-Pèrez *et al.*, 2021).

Social anxiety seems to occur more often among adolescents, with a prevalence of about 9 percent (Birstein *et al.*, 2011) and an onset that averages around age 13 (Kessler *et al.*, 2005). Adolescents, defined as "digital natives," continually fluctuate between the real relational and digital worlds (Chandra, 2016), and this facilitates the expression of experiences using the symbolic language of technology. Emblematic are virtual reality interventions that combine creative arts, such as painting and sculpture, in the treatment of social difficulties (Zeevi, 2021).

Studies on VRET are still limited although they show enough promise (Kothgassner & Felnhofer, 2021). An early study of the feasibility of VRET interventions on public speaking anxiety (Kahlon *et al.*, 2019) evaluated the effectiveness of a single-session virtual exposure intervention in adolescents (13-16 years old). The intervention proved effective in terms of reducing scores in the behavioural, cognitive and physiological dimensions of public exposure anxiety. The study proves the still controversial effect of "feeling present" as a moderator in treatment outcome.

An additional study of adolescents evaluated the feasibility of VR interventions in individuals with social anxiety (Parrish *et al.*, 2016).

The intervention proposed two public scenarios, during a party and in a public speaking context, which demonstrated total immersion of subjects to the point of eliciting the experience of anxious distress typical of real-world situations. Cast in the different environments of everyday school life (e.g., classroom, gymnasium, hallway, etc.), the study by Sarver and colleagues (2014) in which social interaction situations with people of different ages, roles, and ethnicities were virtually reconstructed is significant. The social demands were related to four tasks: conversation initiation, conversation maintenance, giving and receiving compliments, and demonstrating assertiveness. These skills were taught and then tested in a virtual context, and the environmental stimuli were under the control of a therapist who modulated the verbal and nonverbal responses of the virtual characters, i.e., the pace and difficulty of the interaction. The protocol included virtual exercises at home as well. The intervention showed feasibility and credibility by both young participants and parents. These results were also maintained in research that implemented the technology of the previous study using avatars, refined the virtual environment including more play controls by the subject and eliminating complete control by the therapist (Beidel *et al.*, 2021).

Ethical issues have been raised in the use of virtual reality in children and adolescents. Effects are noted on the physical level, such as cybersickness, sleep-wake or eating alterations and visual disturbances, brought about by the blue light emanating from the devices and reduced physical activity; on the psychosocial level, alarm is mainly directed toward the possible development of pathological forms of addiction (Kaimara *et al.*, 2022). In any case, it is recommended to limit the use of the devices to minors 13 years of age and older (Yamada-Rice *et al.*, 2017).

School phobia in adolescent: the use of the VRET

Gradual and nongradual exposure techniques have also been found to be effective in treating context-specific phobias, such as school phobia. School phobia is characterized by elevated levels of anxiety and fear of school-related events. The consequence of this phobia is often chronic refusal to attend school, to avoid adverse events such as public

speaking, giving examinations but also events related to fear of being bullied or experiencing social difficulties. Avoidance can lead to consequences in emotional and social development by increasing the risk of significant impairment of a person's mental health. Clinical practice with children suggests the need for flexibility and creativity. Virtual reality meets these requirements; moreover, being interesting, it increases children's motivation to take part in treatment. As early as 2005, Wiederhold and colleagues proposed treatment procedures for school phobia based on virtual reality. In a simulation set in school, children performed exercises aimed at developing coping skills; the exercise was, then, repeated in a virtual and protected environment until adequate results were obtained. J. Gutiérrez-Maldonado and colleagues (2009) developed a series of virtual environments that could be effective in treating children with school phobia using a sample of 36 children aged 10 to 15 years. The first phase consisted of creating an avatar. The anxiety-triggering elements and situations included in the settings were selected based on the most up-to-date scientific literature related to the most often encountered school fears and concerns. Each environment, to which they were exposed, had two levels of interaction: easy and difficult, depending on the performance required and the level of anxiety generated by the stimuli. The first environment was the school (hallways, outdoor courtyard, entrance, and the doors of different classrooms). Depending on the level chosen, there were two or more interactive characters with whom it was necessary to communicate to find specific locations. The exercise ended with the ringing of the bell. The second environment was the classroom. Where the level of difficulty is determined by the type of response of the avatars simulating fellow students and the teacher. In the proposed exercises, the child had to first introduce himself and then, interact with classmates who were kind and forgiving in the easy level and intimidating in the difficult level. Post-treatment results show a significant decrease in school-related fears supporting the effectiveness of virtual reality and customized environments to address and treat fears and anxieties related to the school setting. Other anxiogenic stimuli to which it is possible to be exposed at school are situations in which public speaking is required. This is one of the most common fears that is accompanied by trembling, blackouts, fear of saying something nonsensical and of not being understood (Grant *et al.*, 2005). Kahlon and

colleagues (2019) subjected 27 adolescents between the ages of 13 and 16 to VRET. During the sessions, participants had to give speeches in an environment depicting a classroom full of students. The results showed a decrease in anxiety symptoms and better coping with the situation they were exposed to.

Vret application in other clinical contexts

The recent development of new VR hardware and software has led to increasing use of these tools in research and treatment of other forms of psychological distress. VR allows patients to learn through reflection on how to do it. Through this experience, it is easier for the therapist to prove to the patient that what seems like fact is a product of his or her mind. Once this concept is understood, individual maladaptive assumptions can be more easily challenged.

Nutrition and eating disorders

In recent years, virtual reality has offered innovative solutions in reducing food cravings, improving body image, and managing emotions in eating disorders (Riva *et al.*, 2016, Riva *et al.*, 2019). Controlled studies have shown at long-term follow-up greater efficacy of VR treatment in the context of eating disorders and obesity than classical cognitive behavioural treatment (Cesa *et al.*, 2013; Ferrer-Garcia *et al.*, 2019; Marco *et al.*, 2013; Manzoni *et al.*, 2016). The first application of virtual reality in this field was in body image research (Saffo *et al.*, 2020). The possibility of developing applications that explore body representations has advanced due to technological development and the use of increasingly realistic and interactive avatars. The ability to change size, weight, and other body characteristics has proven to be of great help to the therapist who can thus explore, for example, the perceived body, the desired body, healthy weight, and subjective weight. The results showed a positive correlation between different scenarios and body image dissatisfaction. In this perspective, VR can be used to represent stressful situations by providing information to the therapist about patients' subjective view of their bodies (Riva *et*

al., 2019). A recent neuroscientific model suggests that eating disorders may reflect a deficit in the processing and integration of multisensory body representations and signals (Riva & Gaudio, 2018; Riva & Dakanalis, 2018). VR allows working on impaired body integration through two strategies:

- *Reference frame shifting*, attempts to change the individual's body self-awareness through focusing and reorganizing body-related memories. This is possible by having the subject relive a negative body-related situation, giving him or her the opportunity to relive it as a spectator or as a protagonist (Akhtar *et al.*, 2017; Riva, 2011);
- *Body swapping* looks to induce in the subject the feeling of owning the virtual body with a different size and shape. This strategy is often coupled with classic Cognitive Behavioural Therapy, CBT, (Gutiérrez-Maldonado *et al.*, 2016*;* Normand *et al.*, 2011).

Finally, virtual reality can be used to reduce anxiety related to food by interrupting the consolidation of negative memories related to food and going to modify the craving itself (Riva, 2017).

Psychosis

VR has also shown effectiveness in the treatment of psychotic disorders, especially in understanding the psychological mechanisms underlying symptoms (Valmaggia, 2017). In studies by Valmaggia (2016) and Rus-Calaffel (2018), VR was used to recreate in a controlled environment the effects of adverse events on the response to social situations. Again, using virtual scenarios it is possible to assess the subject's functional capacity, cognition, and social competence (Freeman *et al.*, 2017). Accordingly, the literature suggests the virtual environment as a safe place in which psychotic symptoms can be assessed (Rus-Calafell *et al.*, 2018; Valmaggia *et al.*, 2016).

More recently, virtual reality treatment has been used to improve cognitive abilities, such as memory and attention, alongside cognitive remedial interventions to reduce symptomatology in patients with psychosis. In cognitive rehabilitation, VR allows the use of a more innovative and motivating approach that can engage the participant more. It gives, in addition, the possibility of creating standardized and reproducible therapeutic environments. The goal is to improve cognitive

processes resulting in improved daily functioning, develop problem solving strategies and social and interpersonal skills (Fernande-Sotos *et al.*, 2020, Wykes & Spaulding, 2011). The study by Wim Veling and collaborators (2016), highlighted how virtual reality-based cognitive behavioural therapy is helpful in reducing paranoia and delusional symptoms. In the study, 170 patients diagnosed with psychosis and healthy controls were examined. The purpose was to test social stress sensitivity by walking 5 times in a virtual bar with different levels of environmental stress determined by population density, ethnic density, and hostility. There were 16 sessions lasting about one hour. The results showed a significant reduction in paranoid symptoms both after treatment and at a 6-month follow-up, while also recording an improvement in interpersonal functioning. In contrast, participants in the control group who underwent classical treatment showed an increase in symptoms. Despite the low number of published studies, all studies had promising results with short-term improvements in social skills and/or social cognition (Fernández-Sotos *et al.*, 2020) with reduction in symptomatology.

Addictions

The first application of VR in addiction was in 2005 in a study conducted by Bordnick and collaborators. The researchers, using virtual environments, assessed craving and responsiveness to desirable cues such as drugs and substances. All participants were exposed to the predicted signs and their responses were measured in subjective and objective terms (drug craving and physiological responses). VREt allows patients to be exposed to situations they say are unbearable. Repeated practice gives patients the opportunity to learn to control their reactions, identifying alternative stress management strategies that they can apply in the real world. The goal of therapy in individuals with addiction is to develop useful defence mechanisms to cope with risky situations. By virtually replaying stressful situations such as bars, casinos, or pubs the subject can develop useful tools to manage these environments (Baumann *et al.*, 2006). For example, in the VRET used in Girard and colleagues' (2009) study, people were asked to virtually crumble cigarettes, with the aim of reducing craving in tobacco-

dependent subjects. The results of this study show a significant reduction in nicotine use in only four weeks of treatment, as well as a low dropout rate.

Discussions and conclusions

The application contexts of virtual reality are quite broad and span technology, industry and health. In the healthcare sector, the use of VR in evaluation and treatment is becoming established (Duarte *et al.*, 2020; Koning *et al.*, 2009) demonstrating its usefulness in various clinical settings, starting with the treatment of anxiety disorders. Virtual reality provides a real-world experience by creating a virtual experience as close to the everyday as possible. These experiences improve an individual's functionality by promoting the enhancement of cognitive abilities.

VR experiences also emotionally engage the user in the situation. In fact, VR allows for a sense of well-being, due to the stimulation of multiple perceptual channels, implemented using auditory and visual feedback, which stimulate the patient's awareness of their own performance. The overall VR experiences allow for improved motivation, program compliance and treatment effect. Finally, it can also be tailored to the subject's needs. Since psychological assessments and interventions depend primarily on active interaction between therapist and patient, virtual reality adds an edge to these interactions by making the process more effective. Virtual reality offers the opportunity to assess human behaviour as accurately as possible through precise testing and controlled training. The new form of exposure carries some advantages over traditional techniques: greater privacy than other in vivo exposure techniques, lower costs, greater control over exposure parameters; it also allows for situations beyond what is possible, facilitates self-training and overlearning, etc. (Alsina-Jurnet *et al.*, 2007; Gutiérrez-Maldonado, 2002).

With the rise of open access apps and software, one can assume the increasing use of these self-guided virtual reality tools without the presence of professionals guiding the exposure exercises. Indeed, evaluating such intervention protocols without the presence of a therapist could provide greater insights into the feasibility and

effectiveness of treatments. Funded collaboration with engineering, programming, and computer professionals could enable the production of increasingly specialized digital products for the treatment of mental disorders, increasing the availability and impact of these tools (Sarver *et al.*, 2014) even within public clinical settings. Indeed, one possible new approach is the combination of VRET interventions with transcranial magnetic stimulation (TMS), transcranial direct current stimulation (tDCS). As shown by several studies, neurostimulation of the dorsolateral prefrontal cortex (DLPFC) influences processing and memory of visual emotional stimuli (Balzarotti & Colombo, 2016). In this light, the combination of VRET and neurostimulation may improve the clinical effectiveness of this approach (Riva *et al.*, 2019; Notzon *et al.*, 2015; Wout-Frank *et al.*, 2019).

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