Exploring potential mechanisms underpinning the therapeutic effects of surfing

Abstract

There is growing interest in surfing as a recreational activity that may facilitate skill development and improved mental health. However, there remains uncertainty regarding the causal processes through which surfing may improve psychological well-being. With the aim to guide future research, we review potential mechanisms that may underpin the psychotherapeutic effects of surfing. A range of plausible factors are identified, including exercise, water immersion, exposure to sunlight, transcendent experiences, reductions in rumination and the satisfaction of basic psychological needs. Further research is needed to clarify the effectiveness of surfing-based therapies and to establish the relative contributions of the causal mechanisms at play.

Exploring potential mechanisms underpinning the therapeutic effects of surfing

"Get in and wrestle with the sea; wing your heels with the skill and power that reside in you, hit the sea's breakers, master them, and ride upon their backs as a king should."
Jack London

From its roots in ancient Polynesian and Hawaiian cultures, the twentieth century saw surfing spread around the world to become a popular sport and leisure activity (Finney & Houston, 1996). Despite the popularity of surfing, there has been little scientific research to date investigating motivations for, and benefits from, surfing. However, several cross-sectional studies have found depression and anxiety to be lower in surfers (Amrhein, Barkhoff, & Heiby, 2016; Levin & Taylor, 2011) and surfing has been found to provide a sense of respite from symptoms of trauma in combat veterans (Caddick, Phoenix, & Smith, 2015a; Caddick, Smith, & Phoenix, 2015b). Furthermore, a small but growing number of studies have also investigated the effects of surfing-based mental health interventions. Although there is variation in specific design, surf therapy programs typically involve group-based surfing instruction, and can contain elements of psychoeducation, self-care and wellbeing discussions, creating a safe-space, socialization, and community and rapport building.

Although still largely preliminary, the results are promising. For instance, studies have found decreases in anxiety and depression in veterans as a result of these programs (Rogers, Mallinson, & Peppers, 2014; Walter et al., 2019). Surf therapy programs for at-risk youth and youth with disabilities have also reported various benefits such as improvements in behavior, social skills, self-esteem, emotion regulation, and psychological well-being (Cavanaugh & Rademacher, 2014; Clapham, Armitano, Lamont, & Audette, 2014; Godfrey, Devine-Wright, & Taylor, 2015; Hignett, White, Pahl, Jenkin, & Froy, 2018; Matos, Santos, Fauvelet, Marta, & Evangelista, 2017; Moore, Clapham, & Deeney, 2018; Morgan, 2010a). It should be noted that surf therapy programs can have additional features (e.g., social interaction) which may also contribute to their benefits above and

beyond the effects of surfing. Nevertheless, the findings are indicative of a potential for surfing as a therapeutic tool and represent a base from which further research can develop.

Although the evidence reviewed above suggests that surfing may have the potential in some circumstances to improve mental health and assist in reducing the burden of some psychological disorders (e.g., depression, anxiety), the underlying physiological and psychological mechanisms involved remain unclear. To our knowledge, this has yet to be systematically investigated and there has been a recent call for future work to investigate the "active ingredients" of surf-based therapies that may contribute to their salutary effects (Walter, Sarkisian, Martínez, & Ward, 2020). The present article provides a review of potential causal mechanisms through which the therapeutic effects of surfing may emerge, with the aim to provide direction and impetus to further research into surfing-based therapies. It is hoped that this article will help researchers and practitioners design future surfing-based mental health interventions and test the relative contribution of these mechanisms. Some of these mechanisms have previously been touched upon in the literature (e.g., developing physical competencies; increasing self-efficacy; Benninger et al., 2020; Marshall, Kelly, & Niven, 2019). However, there are a number of mechanisms yet to be touched upon. By linking relevant physiological, psychological, and psychotherapy research, we also suggest a range of novel pathways that remain unexplored in the surfing-focused literature. We begin by first discussing relevant physiological and psychological mechanisms involved in physical exercise and water immersion, before discussing the role of immersion in scenic natural environments, self-transcendent positive emotions, and the ability of surfing to satisfy basic human needs for relatedness, autonomy, and competence.

Physiological and Psychological Mechanisms Underpinning the Therapeutic Effects of Surfing

Exercise. In cases where surfing does help mental health, perhaps the most obvious potential reason why may be because it is a form of physical exercise. A large corpus of research now suggests that physical exercise may be beneficial for the treatment of depression and anxiety (see Rebar et al., 2015). There are a range of physiological mechanisms through which exercise improves well-being. Firstly, exercise can increase levels of brain-derived neurotrophic factor (Szuhany, Bugatti, & Otto, 2015): a protein which is reduced in individuals with depression (Karege, Vaudan, Schwald, Perroud, & La Harpe, 2005), and increases after treatment with antidepressants (Zhou et al., 2017). Aerobic exercise also has anti-inflammatory effects, as seen through a reduction in inflammatory cytokines such as tumor necrosis factor alpha (TNF-α; Beavers, Brinkley, & Nicklas, 2010). Aerobic exercise can also increase endocannabinoid levels (Sparling, Giuffrida, Piomelli, Rosskopf, & Dietrich, 2003), which can have further anti-inflammatory effects (LoVerme et al., 2006).

Chronic inflammation is a trans-diagnostic mechanism involved in numerous manifestations of psychopathology (see Miller & Raison, 2016), and over-expression of inflammatory hormones such as TNF-α can increase symptoms of depression such as fatigue, anhedonia, and reduction in self-care (Ma, Zhang, & Baloch, 2016). Furthermore, a deficiency in endocannabinoids is sufficient to produce anxiety and depression-like symptoms at a pre-clinical level (Christensen, Kristensen, Bartels, Bliddal, & Astrup, 2007; Gorzalka & Hill, 2011; Nissen et al., 2008), a suppression of positive affective memories (Horder, Cowen, Di Simplicio, Browning, & Harmer, 2009; Horder, Harmer, Cowen, & McCabe, 2010), and a decrease in neural responses to rewarding stimuli (Horder et al., 2009; Horder et al., 2010). Facilitating endocannabinoids can inhibit the reuptake of serotonin, norepinephrine, and dopamine (Gorzalka & Hill, 2011; Haj-

Dahmane & Shen, 2011), as well as increase the firing rate of these neurotransmitters (Gorzalka & Hill, 2011). These are the mechanisms through which antidepressants function, and increases in serotonin and dopamine are related to the regulation of sleep, mood, emotion, reward, motivation, memory, and attention (Davis, Alderson, & Welsh, 2000; Meeusen, Watson, Hasegawa, Roelands, & Piacentini, 2006).

Depending on the conditions of the surf, surfing can involve a mix of continuous and interval exercise (Mendez-Villanueva & Bishop, 2005). For instance, a typical session of surfing may involve paddling at near maximum intensity to get in position for a wave, followed by an intensive “pop up” to a standing position, and then a continued short burst as the surfer rides the wave, followed by a paddle back to the “line up”, which can vary in length. These exact times may vary, but once the surfer is competent, surfing often involves high-intensity exercise in short bursts followed by some minutes of cool down until the next set of rideable waves (Mendez-Villanueva & Bishop, 2005). However, if the waves are constant or unpredictable, or if there are strong currents that need to be negotiated, a surfing session may more closely resemble moderate-intensity continuous training. Previous research suggests that a typical recreational surfer may be paddling around 45-50% of the time, remaining stationary 35-40% of the time and only wave riding for 4-5% of the time (Meir, Lowdon, & Davie, 1991; Mendez-Villanueva & Bishop, 2005). In the most extensive testing to date of the effects of surfing on heart rate, LaLanne et al. (2017) monitored the heart rate of 228 recreational male surfers and found that the average heart rate generally ranged between 100-160bpm. The vast majority of their sample had an average heart rate between 55–85% of age-predicted maximum heart rate over the course of the surfing session, thus falling in line with definitions of moderate-to-vigorous intensity exercise. Regarding surf therapy programs that typically use beginner surfers, it is possible that less experienced surfers may either have a higher or lower energy output. Beginner’s energy output could be higher because they may be less fit in

the specific movements required by surfing or their energy output could be lower if they are beginning in calmer conditions with less paddling. Further research is needed into the moderating role of conditions and experience in determining aerobic output in surfers. Yet exercise seems a plausible mechanism that may underlie some of the reported benefits of surfing.

Water immersion. In addition to exercise, additional factors may be at play during surfing sessions that may also result in beneficial physiological and psychological changes. One such factor is immersion in water, which can result in acute decreases in core body temperature. Shevchuk (2008) suggests that one contributing factor to the prevalence of anxiety and depression may be that the typical modern industrialized lifestyle lacks evolutionarily-common physiological stressors, including frequent acute changes in body temperature. That acute mild hyperthermia improves psychological wellbeing is supported by anecdotal evidence from winter swimming studies (e.g., Huttunen, Kokko, & Ylijukuri, 2004), and complementary experimental work demonstrating plausible physiological mechanisms. For instance, studies have found that cold exposure leads to the release of norepinephrine (Janský et al., 1996; Jedema et al., 2008; Jedema & Grace, 2003; Leppäluoto et al., 2008), which has been linked to the pathophysiology of mood and anxiety disorders (Ressler & Nemeroff, 1999), and plays an important role in the behavioral response to stress (Aston-Jones, Valentino, Van Bockstaele, & Meyerson, 1994; Foote, Bloom, & Aston-Jones, 1983). As with physical exercise, the release of norepinephrine suggests that cold immersion may be able to reduce inflammation, as norepinephrine can reduce TNF-α (Hu, Goldmuntz, & Brosnan, 1991), and macrophage inflammatory protein-1α (Haskó et al., 1998), and anecdotal evidence suggests that cold water adaptation can help relieve symptoms of conditions associated with chronic inflammation such as arthritis (Harper, 2012).

Naturally, potential “cryotherapeutic” effects of surfing are likely to only emerge in colder conditions. Surfing is carried out worldwide in water temperatures ranging from lower than 0°C to

over 30°C, and temperatures at the higher end of this range are unlikely to reduce core body temperatures sufficiently for cryotherapeutic effects to emerge. Preliminary research suggests that the amount of cold exposure required for cryotherapeutic effects to emerge depends on a combination of the temperature of the water and the length of immersion. For instance, Šrámek, Šimečková, Janský, Šavlíková, and Vybiral (2000) found that 1-hour immersion in 20°C did not lead to significant increases in norepinephrine release. However, they found that 1-hour immersion at 14°C led to a 530% increase in norepinephrine as well as a 250% increase in dopamine. These effects may appear more rapidly with exposure to even lower water temperatures. For instance, Leppäluoto et al. (2008) found substantial increases in norepinephrine from 20-second immersion in 0-2°C water.

Although, to our best knowledge, no research has been conducted looking specifically at neurophysiological changes from exposure to cold in surfers, research suggests that surfing can involve changes to body temperature, even when surfers are wearing wetsuits. For instance, Warner, Nessler, and Newcomer (2019) and Corona, Simmons, Nessler, and Newcomer (2018) found that surfing led to significantly decreased skin temperatures at several locations, especially the legs, lower back and forearms where skin temperature dropped below 30°C after only a 40-minute surf session. The average water temperature in these studies were 16.0 ± 0.1°C and 14.6 ± 0.2°C, which reflects common water temperatures for winter and spring surfing in many surfing locations around the world such as California, southern and western Australia, and much of Europe. Although some surfing stops in winter, many surfers continue surfing in winter and, indeed, many surfing locations around the world receive their best conditions during winter months. As such, it is plausible that many surfers around the world are regularly experiencing some acute reductions in body temperature.

One key difference between the surfing experience and most experimental research into cold water immersion is that surfing also involves the immersion of the face in water. Research into the *mammalian diving response* (see Michael Panneton, 2013) suggests that facial immersion in cold water may reduce inflammation through stimulating the vagus nerve (Bonaz, Sinniger, & Pellissier, 2016; Foster & Sheel, 2005). As such, the combination of lowered core temperature and the mammalian dive response might interact to make surfing a potent method for disrupting chronic inflammation, potentially acting as a preventative or mitigating factor against a decline in mental wellbeing due to the link between chronic inflammation and psychopathology (Miller & Raison, 2016). Nevertheless, rigorous research is yet to be conducted testing the effects of cold-water immersion as a therapeutic strategy for the treatment of mental health conditions. However, it appears a promising direction for future research, and in cases when surfing appears to have benefits for mental health, it is plausible that immersion in water may play a role.

Exposure to natural light. Another potential factor is that surfing typically involves exposure to bright natural light, which can help regulate circadian rhythm and facilitate adequate quality and quantity of sleep through increasing the amplitude of the nighttime melatonin secretion peak (Dumont & Beaulieu, 2007; Emens & Burgess, 2015). Disruptions in circadian rhythm have been linked to the development and maintenance of many psychological disorders, including depression, bipolar disorder, anxiety disorders and attention deficit hyperactivity disorder (ADHD; Baird, Coogan, Siddiqui, Donev, & Thome, 2012; Dueck, Thome, & Haessler, 2012; Germain & Kupfer, 2008; Melo, Abreu, Neto, de Bruin, & de Bruin, 2017). Furthermore, meta-analytic evidence suggests that exposure to bright light can reduce symptoms of unipolar and bipolar depression (Perera et al., 2016; Tseng et al., 2016).

In addition to light through the eyes, surfing also often involves exposure of the skin to significant levels of ultraviolet radiation from the sun. Skin exposure to sunlight can lead to a

short-term increase in feelings of well-being through the production of beta-endorphins (Fell, Robinson, Mao, Woolf, & Fisher, 2014; Jussila, Huotari-Orava, Ylianttila, Partonen, & Snellman, 2016). Further, exposure to sunlight may also play a role in modulating serotonin levels through its effects on Vitamin D synthesis (see Patrick & Ames, 2015). Exposure of the skin to UVB radiation leads to the conversion of 7-dehydrocholesterol (7-DHC) to previtamin D3 (preD3), which is then transformed into Vitamin D3 (Holick, 2004). Vitamin D deficiency is common worldwide (Hilger et al., 2014), raising concerns due to the link between low levels of Vitamin D and a range of health conditions, including depression (Jorde, Sneve, Figenschau, Svartberg, & Waterloo, 2008; Milaneschi et al., 2010), ADHD (Goksugur et al., 2014), schizophrenia (Kinney et al., 2009; McGrath et al., 2010), and autism (Patrick & Ames, 2014). Large-scale randomized trials are still needed though to confirm the role of Vitamin D in many disorders (Parker, Brotchie, & Graham, 2017). Nevertheless, when surfing has benefits for mental health, it is plausible that sunlight exposure may play a role, whether through helping maintain circadian rhythm, or acute changes in neuro- and biochemistry.

Immersion in natural environments. A crucial aspect of surfing is the fact that it is typically conducted in scenic natural environments. Philosophers and authors have long written about the therapeutic effects of beautiful nature (Muir, 2008; Thoreau, 1854), and a large amount of empirical research now evidences its positive physiological and psychological outcomes (McMahan & Estes, 2015; Twohig-Bennett & Jones, 2018), such as reduction in stress through decreased activation of the sympathetic nervous system, increased activation of the parasympathetic nervous system, and decreased blood pressure and cortisol levels (Antonelli, Barbieri, & Donelli, 2019; Farrow & Washburn, 2019; Kobayashi et al., 2018).

Research suggests that perceived aesthetic quality predicts the psychological benefits of exposure to nature (Van den Berg, Koole, & van der Wulp, 2003; Zhang, Piff, Iyer, Koleva, &

Keltner, 2014). Of relevance, the presence of water is a key determining feature of the aesthetic appeal of natural environments (Kaplan & Kaplan, 1989; Nasar & Li, 2004). From an evolutionary perspective, coastal environments are rich in resources, and this would have been conducive to the survival of early humans, and, as such, the preference for blue spaces may be an evolved adaptation (Kaplan & Kaplan, 1989; White et al., 2010). Ulrich (1995) suggests that the stress-reducing capabilities of physical environments might correspond with the extent to which they are conducive to survival, and corresponding research suggests that 'blue spaces' may have benefits for mental health which may be comparable or even superior to the benefits of "green spaces" (Britton, Kindermann, Domegan, & Carlin, 2018; Gascon, Zijlema, Vert, White, & Nieuwenhuijsen, 2017; White, Pahl, Ashbullby, Herbert, & Depledge, 2013). Indeed, previous research has found living closer to the ocean to be associated with better mental health (Garrett, Clitherow, White, Wheeler, & Fleming, 2019; Pasanen, White, Wheeler, Garrett, & Elliott, 2019).

These beneficial psychophysiological effects may also be amplified by exercise, as combining exercise and immersion in natural environments may be more beneficial than either on their own (Thompson Coon et al., 2011). Complementary research suggests that outdoor adventure-type exercise conducted outdoors may also have increased benefits over traditional exercise activities through increasing adherence to the exercise (Glover & Polley, 2019) and that benefits may emerge in shorter periods of time (Peacock, McKenna, Carless, & Cooke, 2019). In sum, the fact that surfing is conducted in natural environments might be a factor in both why people surf and also the benefits that they gain from surfing.

Reducing rumination. In addition to beneficial physiological changes, immersion in natural environments may have benefits for mental health through reducing rumination: a transdiagnostic mechanism implicated in the onset, development and maintenance of numerous mental health difficulties (Busch, Pössel, & Valentine, 2017; McLaughlin & Nolen-Hoeksema, 2011).

Rumination refers to the repetitive and passive focus on the content, causes, and consequences of one's thoughts or emotions related to unresolved personal goals or concerns, and interferes with effective problem-solving (McLaughlin & Nolen-Hoeksema, 2011).

Conceptualising rumination as a habit (see Watkins & Nolen-Hoeksema, 2014) has important implications for understanding how the therapeutic effects of surfing may emerge. Interventions focused on changing individual beliefs, attitudes, and intentions through providing new corrective information (e.g., thought challenging in cognitive-behavioral therapy) are often ineffective at reducing rumination because they do not address the patterns of context-response learning that maintain habits (Longmore & Worrell, 2007). Disrupting environmental factors can be a more efficacious strategy for managing rumination by breaking the habitual ruminative cycle. For example, as surfing tends to occur outdoors, being immersed in such natural environments may encourage surfers to be more externally, as opposed to internally focused—a response that is incompatible and thereby conflicts with the unwanted habit—thus reducing attention towards excessive worries and/or negative thought processes (see Kaplan, 1995).

Indeed, research by Bratman, Hamilton, Hahn, Daily, and Gross (2015) found that a 90-minute walk through a natural setting significantly lowered both rumination and activity in a brain region linked to rumination (the subgenual prefrontal cortex). This finding dovetails with qualitative evidence suggesting that surfing can function as a period of short-term positive distraction (Caddick et al., 2015b). In other words, surfing may help to divert one's attention away from one's depressed mood or excessive worries and its consequences through engagement in an engrossing activity that is capable of providing positive reinforcement (Csikszentmihalyi, 1997; Nolen-Hoeksema, 1991). In this way, surfing, through its ability to facilitate positive distraction, can be seen as an adaptive alternative to rumination. However, research has yet to systematically investigate the extent to which surfing can disrupt patterns of rumination, either during or

following engagement in the activity. Future research could investigate the extent to which surfing is related to reduced attention towards one's negative thoughts, more positive appraisals of difficult situations and more adaptive problem solving.

Flow states, spirituality and personal transformation. Indirect evidence suggesting a potential for surfing to disrupt negative rumination comes from research into the experience of *flow*. Csikszentmihalyi (1997) conceptualized flow states as involving a complete engrossment in an enjoyable activity that results in a loss of a sense of self and a sense of time. Flow experiences can directly counter negative rumination (Watkins et al., 2011), and Partington, Partington, and Olivier (2009) found that flow states were common in big wave surfers and suggested they may be a key mechanism leading to improved mood and higher self-esteem in this group. Importantly, flow states have also been reported in recreational surfers (Morgan & Coutts, 2016).

Flow states may also contribute to why surfing often takes on a spiritual character for those who surf—a sentiment was summed up by surfing pioneer Gerry Lopez who opined that "those moments when you were completely focused on riding a wave are actually kind of spiritual…religious moments" (Evers, 2010, p. 27). Surfing has in fact been described as functioning as a type of nature-religion for many people (Taylor, 2007). Beautiful nature is a common elicitor of the emotion of awe (Keltner & Haidt, 2003; Shiota, Keltner, & Mossman, 2007), which is member of a class of emotions which have been referred to as the *self-transcendent emotions* (see Stellar et al., 2017). Conceptually related to what Maslow (1962) termed "peak experiences", Keltner and Haidt (2003) conceptualize awe as an emotion elicited by the perception of being in the presence of something vast which overwhelms existing cognitive schemas of the world, and thus requires accommodation of these schemas. They further suggest awe to be a quintessential religious emotion, and empirical research suggests that awe and related emotions can

indeed increase spirituality (Saroglou, Buxant, & Tilquin, 2008; Van Cappellen & Saroglou, 2012; Van Cappellen, Saroglou, Iweins, Piovesana, & Fredrickson, 2013).

Supporting Maslow's (1962) contention that peak experiences can facilitate personal transformation, experiencing awe has been linked with life satisfaction (Rudd, Vohs, & Aaker, 2012) and pro-social behavior (Piff, Dietze, Feinberg, Stancato, & Keltner, 2015; Zhang et al., 2014). Awe has also been found to induce a state referred to as the "small self" (Piff et al., 2015), which involves a reduction in self-focused attention and it is likely that this state contributes to the experience of flow states and spiritual experiences in surfers. Similar to exercise and cold immersion, as described above, previous research has also found that awe also reduces pro-inflammatory cytokines (Stellar et al., 2015). Pertinently, Anderson, Monroy, and Keltner (2018) found that experiences of awe mediated the positive effects of another nature based sport (e.g., whitewater rafting) in veterans and at-risk youth, providing indirect evidence awe may play a similar role in mediating potential benefits of surfing experiences. However, further research is needed, as the role of awe in the context of surfing has yet to be thoroughly explored.

Nevertheless, the extant research on nature-experiences, spirituality and awe suggests that surfing can, in at least some circumstances, help people transform their lives. Indeed, surfing encompasses the critical properties of nature-based experiences that have been suggested to be 'transformative' (Wolf, Ainsworth, & Crowley, 2017; Wolf, Stricker, & Hagenloh, 2015). Specifically, surfing enables immersion through the highly physical nature of the activity, and the physical, mental, and emotional challenges involved, along with the social aspects of the experience. Regular participation in the activity within natural settings may further enhance the transformative potential of surfing and therefore its therapeutic potential.

Satisfaction of basic needs. In cases where surfing does lead to significant improvements in people's lives, this may also be in part due to changes in basic need satisfaction. According to

Ryan and Deci (2000, p. 74), a basic need is “an energizing state that, if satisfied, conduces toward health and well-being but, if not satisfied, contributes to pathology and ill-being”. *Self-Determination Theory* (SDT; Ryan & Deci, 2000) posits that humans possess three basic needs: relatedness, autonomy, and competence. Satisfaction of these needs has been found to be related to overall well-being (Milyavskaya & Koestner, 2011), and fluctuations in need satisfaction have been found to predict fluctuations in well-being (Reis, Sheldon, Gable, Roscoe, & Ryan, 2000; Sheldon, Ryan, & Reis, 1996). Research has also found basic need satisfaction to be a key mechanism involved in the benefits of physical activity (Gunnell, Crocker, Wilson, Mack, & Zumbo, 2013; Mack, Meldrum, Wilson, & Sabiston, 2013; Sylvester, Mack, Busseri, Wilson, & Beauchamp, 2012) and has previously been discussed within the context of adventure sports (Houge Mackenzie & Brymer, 2020).

Relatedness. The notion that humans are fundamentally motivated to develop and maintain relationships has been a running theme cutting across multiple paradigms throughout the history of psychological science (Baumeister & Leary, 1995). Feelings of belonging are related to well-being, and a deficit in social connectedness is a specific risk factor for the development of mental illness (Cruwys et al., 2013; Pohl, Young, & Bosch, 2018; Saeri, Cruwys, Barlow, Stronge, & Sibley, 2018).

We believe that surfing has the potential to satisfy relatedness needs through several pathways. Firstly, surfing can provide an opportunity for the development and strengthening of interpersonal relationships through providing an interface for socializing (Waitt & Warren, 2008). The natural environments that surfing is conducted in may help build social bonds, as previous research suggests that beautiful natural environments can increase pro-social behavior (Weinstein, Przybylski, & Ryan, 2009; Zhang et al., 2014), facilitate social interactions (Ruso & Atzwanger, 2003), and reduce aggressive behavior (Kuo & Sullivan, 2001a, 2001b; Poon, Teng, Wong, &

Chen, 2016). In addition to facilitating positive interpersonal encounters, previous research also suggests that awe-inspiring nature increases broader feelings of connectedness to humanity (Piff et al., 2015; Shiota et al., 2007; Van Cappellen & Saroglou, 2012), which may also help satisfy the human need to feel connected. As such, surfing may help people form social bonds, and may be able to help develop a general sense of connection to humanity.

Surfers may over time also become deeply attached to specific places (Anderson, 2014). Regular engagement with natural places is known to facilitate such connection and, ultimately, attachment (Hidalgo & Bernardo., 2001; Morgan, 2010b). As a multidimensional construct (Halpenny, 2010; Ramkissoon, Smith, & Weiler, 2013), place attachment encompasses both functional (place dependence) and emotive (place identity, place affect and place-social bonding) aspects of human relationships with place (Devine-Wright & Clayton, 2010; Lewicka, 2008), and nature-based settings in particular (Bricker & Kerstetter, 2000; Korpela, Ylan, Tyrvainen, & Silvennoinen, 2009). Surfers may develop attachment across all of these dimensions and therefore a deep belonging to specific surfing locations. Functional attachment will occur in littoral settings that provide the environment that is necessary to perform the activity. Emotive attachment accrues from the building of strong ‘surf identities’ often developed at the particular beach where a person grew up (Anderson, 2014). Affective bonds arise out of pleasurable surfing experiences that create well-being (Kyle, Graefe, Manning, & Bacon, 2004), and from positive social experiences (Kyle, Graefe, & Manning, 2005), all of which contribute to the emotive connection to nature and place, and therefore may help satisfy the basic human need for relatedness.

In addition to attachments with specific places, experiences with beautiful nature can also lead to broader feelings of connectedness to nature as a whole (Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2009). Inspired by earlier theorists (e.g., Wilson, 1984), it has more recently been suggested that feeling connected to nature can help satisfy relatedness needs (Mayer et al., 2009;

Passmore & Howell, 2014), and connectedness to nature has also been suggested to be a basic need in its own right (Baxter & Pelletier, 2018; Hurly & Walker, 2019). Indeed, meta-analyses have found connectedness to nature to predict positive outcomes such as eudaimonic well-being, positive affect, vitality, and life-satisfaction (Capaldi, Dopko, & Zelenski, 2014; Pritchard, Richardson, Sheffield, & McEwan, 2019). Furthermore, supporting its unique effects on wellbeing, Zelenski and Nisbet (2014) found that connectedness to nature predicted well-being even when controlling for the effects of other subjective connections (e.g., social connections).

Although extant research is limited, surfing has previously been suggested to have the ability to connect people to nature (Moriarity & Gallagher, 2001), and Levin and Taylor (2011) found that 75% of sampled surfers reported feeling a connection with God, nature, or the universe while surfing. Previous research suggests that extreme sports conducted in natural environments can lead to increased respect for nature and a changed perspective regarding the relationship between humanity and nature, such that humanity is viewed as being a part of, rather than separate from, nature (Brymer & Gray, 2010). As such, surfing may represent an efficacious way to connect people to each other and to nature, and therefore may help to satisfy relatedness needs.

Autonomy. The second fundamental need posited by SDT is autonomy: the need for individuals to feel free from outside influence and be able to act in line with their values. Autonomy closely overlaps with the concept of authenticity, or being one's "true self" (Kernis & Goldman, 2006). Supporting its conceptualization as a basic need, meta-analytic evidence suggests autonomy is strongly linked with subjective well-being (Yu, Levesque-Bristol, & Maeda, 2018). Furthermore, authenticity has also been linked with wellbeing (Lakey, Kernis, Heppner, & Lance, 2008; Schlegel & Hicks, 2011; Wood, Linley, Maltby, Baliousis, & Joseph, 2008), and may help foster positive interpersonal relationships (Baker, Tou, Bryan, & Knee, 2017; Brunell et al., 2010; Tou, Baker, Hadden, & Lin, 2015; Wickham, Williamson, Beard, Kobayashi, & Hirst, 2016).

There is a long tradition of experiences with nature being associated with freedom and authenticity (e.g., Krakauer, 2009; London, 1903; Thoreau, 1854). Many aspects of modern life impose on people's autonomy and nature can provide opportunities for people to achieve feelings of freedom and authenticity (Clayton, 2003; Kaplan & Talbot, 1983; Kellert, 2003). At the trait level, connectedness to nature has been found to be related to autonomy (Nisbet, Zelenski, & Murphy, 2011), and being exposed to nature has been shown to increase feelings of autonomy (Weinstein et al., 2009). Specifically, Weinstein et al. (2009) found an interaction whereby the more immersed participants felt in nature, the more autonomous they felt. This suggests that activities, such as surfing, that immerse people in natural environments may be especially beneficial for increasing feelings of autonomy.

Indeed, surfing has a long history of association with freedom from the demands of modern life (Booth, 1994; Olivier, 2010), and much of surf culture has involved the idea of surfing in wild, natural places as a way to get in touch with one's authentic self (Sears, 1998). Furthermore, surfing may additionally benefit autonomy through the self-paced learning that is intrinsic to surf-based exercise (Marshall et al., 2019). When surfing, people can typically choose when they want to surf, how they want to surf, which waves to go on and so forth. The suggestion that surfing may be able to increase feelings of autonomy is also supported by previous research in the context of extreme sports that has found that extreme sports can facilitate different forms of freedom such as the freedom from constraints, freedom from fear, and freedom from the need for control (Brymer & Schweitzer, 2013). Surfing may also facilitate these different forms of freedom, and thus help satisfy the need for autonomy, although further empirical research is needed to confirm this .

Competence. According to SDT, competence needs are met by the development of skills and subsequent feelings of mastery over the environment. Important to the satisfaction of competence needs is that the difficulty of the task is matched to a person's skill to facilitate the

experience of flow, which results in rapid increases in mastery (Csikszentmihalyi, Abuhamdeh, & Nakamura, 2014). The unique context of a beach, with a multitude of waves requiring differing levels of expertise, naturally lends itself to a situation in which each person can make autonomous decisions about their abilities, thus providing the opportunity for appropriate matching of current competence with wave difficulty. This ability for self-regulated skill development in turn allows individuals to grow in confidence within the comfort of their chosen level of progression in the sport (Marshall et al., 2019). As such, surfing may help satisfy competence needs as it can provide feelings of mastery over one's environment through learning a difficult task.

Another mechanism through which surfing may enable the development of competencies is through graded exposure to distress tolerance. Coming into contact with painful emotions is a key component of many psychotherapeutic approaches (see Carey, 2011), such as exposure to threat-related cues in some Cognitive-Behavioral Therapies (Pompoli et al., 2018), developing skills to tolerate distress in Dialectical Behavior Therapy (Linehan, 2014; Valentine, Bankoff, Poulin, Reidler, & Pantalone, 2015), and working in the transference in psychodynamically-oriented therapies (Levy & Scala, 2012). Surfing can often involve being exposed to uncomfortable situations. For instance, being "pounded" by a large wave involves learning to let go and accept that the wave will hold you for a period of time. Furthermore, dropping into each wave carries a large amount of uncertainty as to how the situation will play out and, as such, this experience may help people develop skills in uncertainty tolerance. Although participating in extreme sports is not always motivated by risk-seeking (Brymer, 2010), these activities may be able to help people become used to risk and uncertainty in their lives. As with rumination, intolerance of uncertainty has been suggested to be another transdiagnostic mechanism implicated in anxiety and depression (Mahoney & McEvoy, 2012; McEvoy, Hyett, Shihata, Price, & Strachan, 2019). In sum, surfing can provide an interface where the individual can develop basic distress tolerance competencies,

including acceptance of uncertainty and distressing sensations. From a psychotherapeutic perspective, this shares similarities with Behavioral Activation (BA) approaches to managing mental health difficulties, which involve reducing a person's avoidance of anxiety-provoking stimuli and increasing their engagement in adaptive and meaningful activities associated with feelings of accomplishment and mastery (Dimaggio & Shahar, 2017; Dimidjian, Barrera Jr, Martell, Munoz, & Lewinsohn, 2011).

Conclusions and Future Directions

We have provided an overview of emerging evidence suggesting mechanisms through which the therapeutic effects of surfing may emerge. Nevertheless, there has, to date, been little research investigating the relative contribution of different mechanisms. As touched on by Marshall et al. (2019), further consideration needs to be given to causal mechanisms in order to provide support to claims of effectiveness of surfing as a therapeutic practice.

Greater understanding of underlying mechanisms may also guide hypotheses about moderating situational factors of the surfing experience. Conditions consisting of long-period groundswell with light offshore winds are almost universally considered more enjoyable to ride, and such conditions are also more aesthetically pleasing, and may facilitate self-transcendent experiences. The size of the wave may also play a moderating roll: surfing smaller waves may be more relaxing, but larger waves may bring a greater sense of excitement and accomplishment. The natural beauty of the surrounds should also be expected to play a role: surfing in more remote areas in pristine conditions, with abundant marine life may be more likely to facilitate self-transcendent experiences compared to surfing in urban beaches.

Future research could consider testing for potential mechanisms by measuring relevant psychological and physiological processes suggested in this article and correspond these with local surf conditions to help clarify the role played by these potential mechanisms, as well as the

conditions that facilitate the greatest benefits of surfing. For instance, physiological and relevant psychological measures could be collected before and after surf sessions, and these could be corresponded with features of the surfing experience such as direction and strength of wind, wave size and period, water temperature and geographical location.

Our review also provides insights for clinical targets of future research into surf therapies. Most of the extant research has utilized populations of veterans or at-risk youth, and research has yet to give much attention whether surfing may be a viable therapy for other populations. Following from our review, we suggest surfing may represent a way to increase general psychological wellbeing for some people who lack social connectedness or connectedness to nature, or autonomy and competence. As surfing appears likely to disrupt chronic inflammation through a combination of exercise, cold immersion and self-transcendent emotions, it may also have potential for the management of psychological conditions associated with chronic inflammation, such as certain manifestations of depression (Miller & Raison, 2016). Furthermore, morning and midday bright light exposure can be efficacious in the treatment of bipolar (Kupeli, Bulut, Bulut, Kurt, & Kora, 2018; Sit et al., 2017; Tseng et al., 2016), and the ability of surfing to provide respite from negative ruminations suggests that it may be of benefit for people who struggle to disengage from repetitively and passively focusing on their thoughts and emotions in an attempt to solve unresolved problems. As such, it may be of specific therapeutic benefit to people with manifestations of obsessive compulsive disorder (OCD) that involve cognitive rituals to quell anxiety brought on by obsessive ruminations (Wahl et al., 2011). In sum, as surfing can target a range of transdiagnostic mechanisms, it may have value in the prevention and management of a wide range of psychological conditions. In other words, surfing may be a transdiagnostic intervention.

Nevertheless, it is important to clarify that we are not suggesting that surfing will always be of net benefit to a participant. More research is needed into when and why benefits of surfing may emerge. There are a number of factors that could mitigate beneficial effects of surfing. Firstly, surfing is not without physical risk. Although an encounter with potentially dangerous marine fauna is perhaps the most commonly feared scenario, the biggest physical threat posed from surfing is from drowning or physical trauma from "wiping out". Serious injury and death do occur, although in comparison to the number of active surfers worldwide, the risk is relatively small. Furthermore, negative experiences while surfing could potentially diminish people's confidence in the ocean. However, these risks are minimized in smaller waves and matching conditions to skill level. Secondly, excessive sun exposure comes with a variety of health risks including skin cancer and cataracts (Armstrong & Kricker, 2001), and there is likely a tipping point where the benefits of sun exposure are outweighed by potential harms. Lastly, although in this article we have drawn links between surfing and a countercultural "hippie" spirit, it must be noted that not all surfing subcultures are entirely prosocial (see McGloin, 2005). Specific situational contexts (e.g. crowded breaks) can sometimes create antagonistic environments that may undermine surfer's confidence and feelings of belonging, and these environments may reduce or eliminate benefits of surfing. Thus, the specific sub-culture of the local surfing scene may be an important moderating factor.

While acknowledging that surfing will not always lead to beneficial outcomes, the emerging evidence suggests that surfing can often have positive effects on psychological well-being. Human beings have a range of physiological and psychological needs, including acute physiological stressors, exposure to natural environments, and feeling related, autonomous and competent. When these needs are not met, mental health suffers. As surfing can help satisfy these fundamental physiological and psychological requirements for optimal mental health, we have argued that it may be an extremely beneficial activity for the prevention and management of a

range of mental health conditions. However, little research to date has investigated the relative contributions of potential mechanisms. Although the emerging research is promising, further research is needed to clarify boundary conditions around the benefits of surfing and to establish the underlying causal mechanisms at play.

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