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Neuropsychology of Cognitive Functions Related to Pro-Environmental Behavior

Çevre Yanlısı Davranışlarla İlişkili Bilişsel İşlevlerin Nöropsikolojisi

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ABSTRACT

The daily habits and behaviors of modern society people harm the environment more than expected. It is well known that in order to protect the inherent values of the natural assets of the world we live in, and to sustain the mutual interaction of people with the environment in a productive manner, necessary precautions should be taken to establish and maintain pro-environmental behaviors. However, people act in different levels of pro-environmental behavior. Although most of the people state that they have a pro-environmental attitude, they cannot transform their attitudes into actual behaviors in their daily lives for various reasons. Examining the mechanisms underlying this phenomenon, known as the attitude-behavior gap, may contribute to the development of interventions that can help to understand how these behaviors differ among individuals and to eliminate this difference between the observed pro-environmental behaviors. At this point, neuroscience studies can provide a more comprehensive explanation of the reasons for the behavioral differences between these individuals, by comparing the performance of individuals with and without pro-environmental behaviors and those who have adopted and not adopting the environmentalist view, on behavioral tasks, and by simultaneously examining the physiological responses that may be related to sustainable behavior. This article will discuss how neuroscience and neuropsychological approach can provide an explanation for these questions through their unique methods.

Keywords: Pro-environmental behavior, sustainable behavior, neuropsychology, neuroscience

ÖZ

Modern toplum insanının yaşamındaki gündelik alışkanlıklarının ve davranışlarının tahmin edilenden fazla bir kısmı çevreye zarar vermektedir. Gerek içinde yaşadığımız dünyanın doğal varlıklarının kendiliğinden olan değerleri nedeniyle gerekse de insanların çevre ile olan karşılıklı etkileşimi nedeniyle çevre yanlısı davranışların yerleşmesi ve sürdürülebilmesi için gerekli önlemler alınması gerektiği bilinmektedir. Ancak insanların çevre yanlısı davranış düzeyleri farklılaşmaktadır. İnsanların büyük bir kısmı çevre yanlısı tutuma sahip olduklarını belirtmelerine rağmen, çeşitli nedenlerle tutumlarını gündelik hayatlarında davranışa dönüştürememektedirler. Tutum-davranış boşluğu olarak bilinen bu fenomenin altında yatan mekanizmaları incelemek bu davranışların bireyler arasında nasıl farklılaştığını anlamaya ve bu farklılığı ortadan kaldırmaya yardımcı olabilecek müdahalelerin geliştirilmesine katkı sağlayabilir. Nöropsikolojik yaklaşım bu noktada, çevre yanlısı davranışları olan ve olmayan bireyler ile çevreci görüşü benimsemiş ve benimsememiş olan kişilerin davranışsal görevlerdeki performanslarını karşılaştırarak ve eşzamanlı olarak ilişkili olabilecek fizyolojik yanıtları inceleyerek, bu kişiler arasındaki davranış farklılıklarının nedenlerinin daha kapsamlı bir biçimde açıklanabilmesine ve böylece de, sürdürülebilir davranışın yerleşmesi için alınabilecek önlemlere katkı sağlayabilir. Burada, bu amaçla nöropsikolojinin ve nörobilimin kullanmış olduğu yöntemler aracılığıyla bu soruya nasıl bir açıklama getirilebileceği tartışılacaktır.

Anahtar sözcükler: Çevre yanlısı davranış, sürdürülebilir davranış, nöropsikoloji, nörobilim

Introduction

In today's world, despite a clear understanding of the necessary steps for environmental conservation and the measures that need to be taken to prevent related potential issues, it is observed that consistent individual behaviors are not sustained, and systematic policies are not maintained at the societal and global levels. Furthermore, it is well-known that individuals' attitudes and behaviors towards the environment directly impact climate change (Stern 1992, Swim et al. 2011), environmental pollution (Stern 2000), and biological diversity (Wilson 1988). Therefore, encouraging pro-environmental behaviors at the individual level is essential to achieve positive outcomes on a global scale and mitigate environmental threats. One of the fundamental questions that needs to be examined at the psychological level is why individuals differ so significantly in their pro-

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environmental attitudes and behaviors. Investigating the factors that contribute to these differences may provide a comprehensive explanation of human-environment interaction in the field of psychology.

Pro-environmental behavior is defined as actions that cause the least possible harm to the environment and, in some cases, even protect it (Steg and Vlek 2009). While a significant portion of the population claims to support pro-environmental behaviors, research results have shown that they do not actually behave in this manner. This phenomenon is referred to as the "attitude-behavior gap" (Kollmus and Agyeman 2002, Kennedy et al. 2009). One barrier to sustain pro-environmental behaviors is the inconsistency between individuals' intentions to perform a behavior and the outcomes they aim to achieve through that behavior. Examples of this situation include a person who wishes to recycle their waste but cannot access recycling bins due to their distance from their home, or an individual who does not want to consume meat but loves the taste of it, thus failing to sustain this behavior. Engaging in pro-environmental behavior results from a decision, and people's decisions are not solely determined by rational consequences (Damasio 1994). Just like in all behaviors, the decision to engage in pro-environmental behaviors is influenced by an individual's emotional state (Brosch 2021, Schneider et al. 2021), motivational condition (Bayes and Druckman 2021), and habits (Verplanken and Whitmarsh 2021).

Differences in the methods used to measure pro-environmental behaviors are also a factor for emergence of this attention-behavior gap. Self-report scales frequently used in the field of psychology measure attitudes, and these findings tend to be interpreted as a predictor of behavioral outcome. However, behavioral differences can best be examined through studies using controlled experimental designs (Lange and Dewitte 2019). At this point, neuroscientific methods and neuropsychological assessments can be used to examine the implicit mechanisms behind the inconsistency between attitudes and behaviors. Undoubtedly, the neural findings obtained with these methods do not reduce the importance of all other factors affecting pro-environmental behavior.

The aim of this review is to discuss whether it is possible to conduct a more detailed examination of the emotional and cognitive processes underlying environmental behaviors by including measurement tools that help us understand the relationship between brain and behavior in environmental psychology research, by including the findings of studies in this field in the literature.

The use of multi-method approaches may enable the development of successful interventions that lead to more pro-environmental decisions in the long term by understanding the neuroanatomical and neurophysiological differences that mediate the psychological, cognitive and emotional mechanisms that cause the gaps between pro-environmental behaviors and attitudes to emerge.

Factors Affecting Pro-Environmental Behavior

According to Stern (2000), the factors that influence environmental behavior are attitudinal factors, contextual forces, personal capacities, and each individual's own habits and routines. Among these, attitudinal factors involve norms, beliefs and values. Personal values become activated in case something a person value is threatened by environmental conditions and at the same time in case this person has a belief that he can do something to remove this threat.

Attitudinal factors among these include norms, beliefs and values. Personal values will become activated when the things a person values are threatened by environmental conditions and at the same time the person has a belief that he or she can do something to reduce that threat. Therefore, the beliefs that a person have influence the norms and attitudes towards the environment over the values that he or she owns (Stern 2000). Considering that the values create a moral responsibility in that they activate values, it can be assumed that the values are fundamentals of environmentalism and pro-environmental behaviors.

These values have been shown as important determinants underlying environmentalist understandings that human life is above everything in the world or see the entire world as a value (Abrahamse and Steg 2013, Steg et al. 2014a, Steg et al. 2014b, Nordlund and Garvill 2002). Norms on the other hand are related to a person’s level of internalization of these values. Although people have norms, they may tend to conform to them when they observe other people behaving differently (Farrow et al. 2017). One other factor that effects the pro-environmental behaviors is a person’s awareness and information level. For example, some people think that they do not have enough information about climate change and therefore they see the following threats as long-term consequences. This factor is considered to be the first step in solving environmental problems by changing people's behavior (Ramsey et al. 2017). The last factor identified by Stern (2000) is habits. It is difficult for people to change the behaviors they engage in every day, which prevents pro-environmental behaviors from being sustainable.

It has been shown that one predictor of the emergence of a particular behavior is the level of controllability of that behavior (Ajzen 1991). In order to carry out pro-environmental behaviors, a person must believe that he can really change the consequences with these behaviors. It has been shown that another factor that determines the level of pro-environmental behavior is locus of control. The perceived level of behavioral control has been found to be associated with people's tendency towards sustainable consumer products, their use of sustainable technology, and their daily pro-environmental behavior (Mohiuddin et al. 2018, Karimi et al. 2021, Fatima et al. 2022).

On the other hand, there are studies showing that all these factors are not effective in maintaining people's pro-environmental behaviors consistently (Ockwell et al. 2009, Gifford 2011, Myers et al. 2012, Hornsey et al. 2016). For this reason, studies have been focused on examining the impact of emotions, especially on the relationship between these factors and pro-environmental behavior. The emotions that a person expects to experience as a result of performing a certain behavior are defined as expected emotions. The stimulation of expected positive and negative emotions in participants regarding climate change positively affected pro-environmental behaviors both directly and indirectly (Odou and Schill 2020). Rezvani et al. (2017) stated that people engage in more environmentally friendly behavior when they expect that they will feel proud of themselves as a result. It has been shown that when pride is experienced in environmental behavior, a person's engagement in such behavior increases, and the feeling of guilt and shame expected as a result of engaging in a behavior that will harm the environment also increases pro-environmental behavior (Ferguson and Branscombe 2010, Harth et al. 2013, Rees et al. 2014).

Pro-Environmental Behavior and Related Cognitive Functions

These behavioral characteristics that differentiate pro-environmental behavior or environmental attitudes appear to be related to two cognitive functions. These cognitive functions will be discussed under the headings of executive functions and social cognitive functions.

Executive Functions

The mentioned individual characteristics, awareness, locus of control and habits, are related to our executive functions, which are among our advanced cognitive functions. Executive functions is an umbrella term. This term covers a range of cognitive functions such as abstract thinking, planning, organizing, rule making, cognitive flexibility, response inhibition, prediction, avoidance of perseverance, self-monitoring and inhibition. Sustaining pro-environmental behaviors depends primarily on the person having knowledge of why he or she should continue this behavior and, in relevant situations, being able to access that knowledge by bringing this information back to his or her consciousness. Being at such a level of awareness and being able to inhibit the behavior that is being used to, maintaining pro-environmental behavior and predicting the consequences of this behavior are behaviors that are mediated by executive functions. There are studies showing that self-control (Steinbeis and Crone 2016), a feature that encompass inhibition and cognitive flexibility, is a mediating factor in maintaining pro-environmental behaviors (Redondo and Puelles 2016, Nielsen et al. 2017, Langenbach et al. 2019, Gómez -Olmedo et al. 2020, Wyss et al. 2022).

Social Cognitive Functions

Cognitive functions that include values, norms and emotions, which are among the factors stated to be related to pro-environmental behaviors in the previous main heading, can be categorized as social cognitive functions. A general classification of social cognitive functions includes emotion recognition, theory of mind, and cognitive and affective empathy. All social cognitive functions interact with emotions. Social cognitive functions lie at the basis of prosocial behaviors, which can be defined as helping other people or developing harmonious relationships with them (Eisenberg and Mussen 1989, Bergin 2014).

It has been reported that the affective empathy (Davis 1983) which can be defined as sharing a person’s emotion while he is experiencing a negative situation and especially moral reasoning which can be defined as the decision process to engage in helping behavior in situations where there is a conflict between a one’s own and other people’s needs are the basis of socially acceptable behavior and that these behaviors are achieved through social cognitive development (Gummerum et al. 2009, Decety and Cowell 2014).

In this context, a parallel can be drawn between pro-environmental behaviors and prosocial behaviors. As a matter of fact, there are findings supporting that these two behaviors are dimensions of sustainable behaviors,

which is a broader set of behaviors that include actions aimed at protecting both nature and social environments (Corral-Verdugo et al. 2011, Tapia-Fonllem et al. 2013).

Relationship Between Pro-Environmental Behavior and Prosocial Behavior

Although the definitions of moral behavior that form the basis of prosocial behavior contain human-specific characteristics; in particular, the moral zones of "harm/protection" and "justice/reciprocity" can be considered to be related to environmental protection behavior, and in this respect, behavior towards the environment also has an ethical dimension. In fact, Kohlberg's Stages of Moral Development are parallel to the classification developed regarding attitudes towards the environment. Attitudes towards the environment can be categorized as ecocentric, anthropocentric and non-environmental attitudes. Ecocentric attitude sees human and non-human creatures as equal and emphasize the importance of biological life and natural processes only because of their own existence (Thompson and Barton 1994, Gardner and Stern 1996, Karpiak and Baril 2008). People with this attitude care not only for humans but for all living things in nature. The anthropocentric view, on the other hand, assumes that nature is important, but considers it because it is for the benefit of people (Karpiak and Baril 2008). In other words, nature is important to the extent that it can benefit people. Finally, non-environmental attitude involves focusing on non-environmental aspects of environmental problems (Kortenkamp and Moore 2001). As mentioned before, these categories regarding environmental behavior are parallel to Kohlberg's stages of moral development. Kohlberg divides the moral development process into three basic stages: pre-conventional, conventional and post-conventional stages. In the pre-conventional stage, the child acts only based on the consequences of his behavior. A behavior is labeled based on the physical or hedonistic consequences obtained, labeling the outcome as good-bad, right-wrong. Although it is defined as a stage that must be overcome along with childhood, there are adults who remain in this phase. In the conventional stage, a person tries to fulfill the expectations of the group, family or state to which he belongs. At this stage, the behaviors that the person defines as moral are actually the moral behaviors determined and accepted by his community. In the post-conventional stage, moral rules are independent of the authorities and people who determine or enforce these rules. At this stage, a moral rule must be applied at all times, in every context (Kohlberg 1973).

Therefore, childhood and adolescence have a level of moral reasoning that corresponds to the conventional and pre-conventional stage. There are studies showing that moral reasoning skills are related to the development of related brain areas and the responses of these areas to emotional stimuli (Şandor ve Gürvit 2019). In addition, in a study on pro-environmental attitudes, similar to Kohlberg's moral development stages, studies evaluating the attitudes of adolescents and young adults towards the environment have also reported findings that anthropocentric attitudes are dominant in these periods (Kahn and Lourenco 2002). In a study conducted in Turkey, the environmentalist attitudes of the participants were determined by the negative consequences that would arise for people as a result of harming the environment (Tuncay-Yüksel et al. 2011).

Models that try to explain people's sensitivity to the environment (Stern et al. 1993, Schultz 2000) argue that this sensitivity continues due to the person's concerns about himself, other people, and nature. Many pro-environmental behaviors involve moral decision-making processes that require making choices that will result in positive outcomes for all humanity and nature itself in the long run, as well as choices that provide an immediate benefit to oneself or a group. For example, people tend to participate less in pro-environmental behaviors in situations where the result takes a long time to be achieved, more people need to participate, and when it is unknown which individuals, institutions or organizations contribute and to what extent (Aitken et al. 2011). These findings can be interpreted as an indication that attitudes towards the environment and pro-environmental behaviors are affected by the moral development stages reached and a moral reasoning skill acquired.

Neuropsychological Findings Regarding Differences in Pro-Environmental Behavior

In this section, the studies mentioned in the previous section that examine the brain features that are related to the cognitive functions underlying pro-environmental behaviors will be discussed. In summary, these studies show the differences in people's pro-environmental behavior levels and they associate the factors that are effective in maintaining pro-environmental behavior with neuropsychological findings.

Findings on Brain Areas Related to Executive Functions

In a study conducted by Baumgartner et al. (2019), participants were assessed for the extent to which they

engaged in pro-environmental behaviors, such as separating their waste or segregating products with environmentally harmful packaging, over the course of five consecutive days. Each day, participants received three messages via their mobile phones prompting them to perform these pro-environmental actions. Subsequently, a general environmental attitude inventory was administered to gauge the participants' overall environmental attitudes. Participants in this study were divided into two groups based on their levels of pro-environmental behaviors as measured by the aforementioned assessments: one group characterized by low pro-environmental behaviors and another by high pro-environmental behaviors. Subsequently, the brain activations recorded during a resting state, without any assigned tasks, were compared between these two groups. As a result of this comparison, it was found that the right lateral prefrontal cortex (PFC) activities of the group exhibiting high pro-environmental behaviors were significantly higher than those of the group demonstrating low pro-environmental behaviors. As described under the executive functions section in the previous section, self-regulation, including inhibitory control, is managed by the lateral prefrontal cortex. The increase in lateral PFC activity is associated with self-regulation, inhibitory control, and executive functions in general (Heatherton and Wagner 2011, Diamond 2013, Jimura et al. 2017). This study suggests that the activity of the right lateral prefrontal cortex can be used as an indicator of the self-control skills necessary to sustain pro-environmental behaviors.

In another study conducted by Lee et al. (2014), differences in the environmental characteristics of a product, such as its environmental impact and the sensitivity of the product's brand to environmental conservation during the purchasing process, were compared based on participants' levels of pro-environmental behavior. During this decision-making process, the electrical activity levels in the brain were recorded. Participants were divided into two groups: those who exhibited environmentally sensitive behaviors and those who did not, and they were further categorized based on their preferences for environmentally sensitive and non-sensitive products in a behavioral task. Brain activities during this decision-making task were recorded using electroencephalography (EEG).

In the group described as "green participants" who exhibited higher levels of pro-environmental behaviors, compared to the "non-green participants," higher theta activity was observed in the frontal lobes during these tasks. Theta waves particularly increase during tasks that involve an increase in attention and working memory load (Summerfield and Mangels 2005). Researchers interpreted the reason for this group difference as an increase in theta activity among "green participants" when they encountered stimuli that were in alignment with their environmental goals. This heightened theta activity facilitated the activation of cognitive representations related to green consumption. Additionally, in these participants, both their personal value systems and reward systems came into play, leading to a greater cognitive load on working memory.

Findings on Brain Areas Related to Social Cognitive Functions

In addition to the studies previously mentioned that have found relationships between moral behaviors and pro-environmental behaviors, there are also studies that examine the neural underpinnings of the social cognitive functions underlying moral behaviors and their contribution to the maintenance of pro-environmental attitudes and behaviors. This article also highlights empathy as one of the most extensively studied social cognitive functions in this context, which was discussed in the third section.

Empathy can be divided into affective empathy and cognitive empathy. In brief, affective empathy involves sharing and experiencing the emotions of others, while cognitive empathy involves understanding the minds of others and interpreting events from their perspectives (Shamay-Tsoory 2015). In today's world, thinking about people living in regions most affected by threatening environmental changes or being sensitive to future generations and striving to leave a healthier world and environment for them are associated with cognitive and affective empathy behaviors. On the other hand, an ecocentric attitude can lead to experiencing this empathy directly toward the world and nature itself. Studies have shown that positive environmental attitudes and high levels of environmental ethics are related to participants' levels of empathy (Berenguer 2010). Therefore, the emotions and neural components of empathy that mediate social behaviors can also contribute to environmental psychology.

In a study conducted by Rosales and Baumgartner (2022), they emphasized the concept of intergenerational sustainability in the context of pro-environmental behaviors. Participants were engaged in a game involving dilemmas related to environmentally friendly behaviors towards future generations. Based on their sustainable behaviors in this game, participants were categorized into two groups. Additionally, participants completed a self-report scale measuring their values, and cortical thickness was measured for both groups.

The group identified as having higher levels of sustainable behaviors was shown to have thicker dorsomedial prefrontal cortex (DMPFC) and dorsolateral prefrontal cortex (DLPFC) compared to the lower group. DMPFC is particularly associated with our social behaviors, where decisions need to take into account the situations of others, including their mental states (Frith and Frith 2006, Frith and Frith 2021). Furthermore, participants with sustainable behaviors also exhibited greater thickness in DLPFC, an important brain structure associated with cognitive control, which is indicative of higher levels of cognitive control. The authors suggested that when considering these two social cognitive functions, the motivation to think about future generations is the starting point for intergenerational sustainability. In this context, the need to suppress rapid and self-centered benefits in favor of achieving outcomes that will benefit a greater number of people in the future becomes essential. Therefore, perspective-taking and self-control may form the foundation of sustainable behavior.

When we witness other people's suffering, perceive injustice in the world, or experience unmet expectations, specific brain areas associated with affective empathy, such as the anterior insula and anterior cingulate cortex, become activated. However, when individuals make decisions in moral scenarios, the ventromedial prefrontal cortex (VMPFC) is activated. The activation of the VMPFC helps individuals make advantageous decisions by incorporating the emotional information generated by possible outcomes of a specific behavior into the decision-making process (Damasio 1994).

In a neuroimaging study, participants were asked to report sustainable behaviors they could engage in the future and unsustainable behaviors they could refrain from in the future, while their brain activities were recorded. Behaviorally, it was found that acquiring sustainable behaviors was easier than giving up unsustainable ones. When participants imagined an increase in their sustainable behaviors, there was an increase in the activity of the VMPFC, which is associated with thinking about the possible outcomes of behaviors. On the other hand, when participants imagined giving up unsustainable behaviors, an increase in right dorsolateral prefrontal cortex (DLPFC) activity associated with inhibitory control processes and a decrease in hippocampus activity related to memory retrieval were observed. These findings led the researchers to suggest that the DLPFC regulates and suppresses brain areas responsible for retrieving unsustainable behaviors from memory, thus contributing to thinking about the future (Brevers et al. 2021).

In another study (Sawe and Knutson 2015), participants were shown images representing situations where national parks were preserved and situations where they were harmed. After viewing these images, participants were asked how much they would donate to prevent this harm, and the brain areas activated during this donation decision were examined. Participants also completed a self-report scale to assess their pro-environmental attitudes. Donation decisions of participants were found to be associated with the activity of the anterior insula, which is related to affective empathy, and participants who reported higher pro-environmental attitudes exhibited greater activation in response to these decisions. Additionally, the presentation of images of national parks increased activity in the nucleus accumbens, a brain region associated with positive arousal and reward. Images depicting harm to the parks increased activity in the anterior insula, associated with negative arousal and corresponding negative emotional experiences, and the interaction of these factors was found to be related to ventromedial prefrontal cortex activity. As participants experienced higher levels of negative emotions and increased anterior insula activity, the amount of donation they were willing to make to protect the parks also increased.

Finally, in another study, participants were shown a group of products and informed that they would be purchasing them. Participants' purchase behaviors were determined based on the features presented to them, and their brain activations were examined during the evaluation of these features. Brain areas associated with perspective-taking, empathy, and moral reasoning were shown to be most active when evaluating the environmental impact of the product. The study suggested that participants take into account how others behave and think when evaluating the environmental impact of products, adding a moral dimension to the purchase behavior (Goucher-Lambert et al. 2017).

Conclusion

This review discusses studies that relate psychological factors influencing pro-environmental behaviors, the cognitive functions associated with these factors, and the neuropsychological findings linking these cognitive functions to pro-environmental behaviors. The aim is to demonstrate the potential contributions of a neuropsychological approach to the field of environmental psychology through empirical findings and provide insights for studies that can bridge these two fields.

Pro-environmental behaviors are influenced by cognitive functions, particularly executive functions like inhibition, cognitive flexibility, and perspective taking. Limited neuroimaging studies in this area have highlighted brain regions associated with these cognitive functions, such as the dorsolateral prefrontal cortex (DLPFC), in relation to environmental decision-making involving emotionally charged environmental stimuli, as well as the anterior insula during decision-making processes related to environmentally relevant stimuli. While cognitive control and executive functions were traditionally believed to be stable in individuals, studies have shown that intervention programs can enhance cognitive control and working memory capacities, particularly in adults (Klingberg 2010, Anguera et al. 2013). Individuals with higher levels of executive functions may find it easier to deviate from behavioral routines that could harm the environment. Additionally, activating social norms through emotionally arousing content can help individuals improve their empathy skills and encourage them to engage in pro-environmental behaviors, first by protecting their immediate living spaces and then by caring for the inherent values of nature. The findings from neuropsychology and environmental psychology studies can collectively contribute to the development of intervention programs in this regard.

Interventions aimed at promoting pro-environmental behaviors through cognitive functions often focus on manipulating attention and memory processes by emphasizing the beneficial or harmful characteristics of stimuli, providing more memorable information. Notably, most studies in this area, as indicated in this review, have primarily focused on climate change (Beattie and McGuire 2015, Carlson et al. 2019, Lehman et al. 2019, Carlson et al. 2020). However, it's crucial to monitor the ecological validity of results obtained from tasks tested in laboratory settings and the effectiveness of applications developed using such data. Given that sustainability is a key aspect of pro-environmental behaviors, assessing the consistency of these behaviors through different technological means is important.

One of the central questions that neuropsychological studies examining pro-environmental behaviors need to address is the specific brain area responsible for sustaining these behaviors. If sustainable behaviors are supported by implicit mechanisms in the brain, the data obtained from the brain can be reliable predictors for these behaviors, as suggested in this article.

Leaving a more sustainable world for future generations involves both pro-environmental behaviors and prosocial behaviors. While various factors influence prosocial behaviors, social cognitive functions constitute their cognitive foundation. Neuropsychological research can shed light on which social cognitive functions form the neurocognitive mechanisms underlying these behaviors and which characteristics should be targeted to develop interventions that promote the acquisition of these skills in children and adolescents. For instance, studies can help determine the content of educational programs for early acquisition of these skills, emphasize specific features of stimuli in advertisements or informative visuals, and evoke emotions that lead individuals to engage in pro-environmental behaviors, particularly behaviors that produce tangible benefits in their personal lives and homes.

Understanding neurocognitive mechanisms can contribute to organizations concerned with protecting nature and the environment and leaving a more livable environment for future generations. Future neuroscience and neuropsychology research, through both laboratory and field experiments, are expected to integrate their findings with those from different disciplines, thereby contributing to more effective policy-making and sustainable societal transformation.

References

Abrahamse W, Steg L (2013) Social influence approaches to encourage resource conservation: a meta-analysis. Glob Environ Change, 23:1773–1785.

Aitken C, Chapman R, McClure J (2011) Climate change, powerlessness and the commons dilemma: assessing New Zealanders' preparedness to act. Glob Environ Change, 21:752–760.

Ajzen I (1991) The theory of planned behavior. Organ Behav Hum Decis Process, 50:179–211.

Anguera JA, Boccanfuso J, Rintoul JL, Al-Hashimi O, Faraji F, Janowich J et al. (2013) Video game training enhances cognitive control in older adults. Nature, 501:97-101.

Baumgartner T, Langenbach BP, Gianotti L, Müri RM, Knoch D (2019) Frequency of everyday pro-environmental behaviour is explained by baseline activation in lateral prefrontal cortex. Sci Rep, 9:9.

Bayes R, Druckman JN (2021) Motivated reasoning and climate change. Curr Opin Behav Sci, 42:27–35.

Beattie G, McGuire L (2015) Harnessing the unconscious mind of the consumer:how implicit attitudes predict pre-conscious visual attention to carbon footprint information on products. Semiotica, 204:253–290.

Berenguer J (2010) The effect of empathy in environmental moral reasoning. Environ Behav, 42:110–134.

Bergin C (2014) Handbook of prosocial education. J Moral Educ, 43:126-129.

Brevers D, Baeken C, Maurage P, Sescousse G, Vögele C et al. (2021) Brain mechanisms underlying prospective thinking of sustainable behaviours. Nat Sustain, 4:433–439.

Brosch T (2021) Affect and emotions as drivers of climate change perception and action: a review. Curr Opin Behav Sci, 42:15–21.

Carlson JM, Lehman BR, Thompson JL (2019). Climate change images produce an attentional bias associated with pro-environmental disposition. Cogn Process, 20:385–390.

Carlson JM, Kaull H, Steinhauer M, Zigarac A, Cammarata J (2020). Paying attention to climate change: positive images of climate change solutions capture attention. J Environ Psychol, 71:101477.

Corral-Verdugo V, Mireles-Acosta J, Tapia-Fonllem C, Fraijo-Sing B (2011) Happiness as correlate of sustainable behavior: a study of pro-ecological, frugal, equitable and altruistic actions that promote subjective wellbeing. Hum Ecol Rev, 18:95-104.

Davis MH (1983) Measuring individual differences in empathy: evidence for a multidimensional approach. J Pers Soc Psychol, 44:113–126.

Damasio AR (1994) Descartes' Error: Emotion, Reason, and the Human Brain. New York, G.P. Putnam.

Decety J, Cowell JM (2014) The complex relation between morality and empathy. Trends Cogn Sci, 18:337–339.

Diamond A (2013) Executive functions. Annu Rev Psychol, 64:135–168.

Eisenberg N, Mussen PH (1989) The Roots of Prosocial Behavior in Children. New York, Cambridge University Press.

Farrow K, Grolleau G, Ibanez L (2017) Social norms and pro-environmental behavior: a review of the evidence. Ecol Econ, 140:1–13.

Fatima N, Li Y, Li X, Abbas W, Jabeen G, Zahra T et al. (2022) Households' perception and environmentally friendly technology adoption: implications for energy efficiency. Front Energy Res, 10:830286.

Ferguson MA, Branscombe NR (2010) Collective guilt mediates the effect of beliefs about global warming on willingness to engage in mitigation behavior. J Environ Psychol, 30:135-142.

Frith CD, Frith U (2006) The neural basis of mentalizing. Neuron, 50:531-534.

Frith CD, Frith U (2021) Mapping Mentalising In the Brain. In: The Neural Basis of Mentalizing (Eds. M Gilead, KN Ochsner):17-45 New York, Springer International.

Gardner GT, Stern PC (1996) Environmental Problems and Human Behavior. Boston, Ally and Bacon.

Gifford R (2011) The dragons of inaction. Psychological barriers that limit climate change mitigation and adaptation. Am Psychol, 66:290-302.

Gómez-Olmedo AM, Carrero Bosch I, Martínez CV (2020) Volition to behave sustainably: an examination of the role of self-control. J Consum Behav, 20:776–790.

Goucher-Lambert K, Moss J, Cagan J (2017) Inside the mind: using neuroimaging to understand moral product preference judgments involving sustainability. ASME J Mech Des, 139:041103.

Guizar Rosales E, Baumgartner T, Knoch D (2022) Interindividual differences in intergenerational sustainable behavior are associated with cortical thickness of the dorsomedial and dorsolateral prefrontal cortex. NeuroImage, 264:119664,

Gummerum M, Keller M, Buchmann M, Malti T (2009) Children's moral motivation, sympathy, and prosocial behavior. Child Dev, 80:442–460.

Harth N, Leach C, Kessler T (2013) Guilt, anger, and pride about in-group environmental behaviour: different emotions predict distinct intentions. J Environ Psychol, 34:18–26.

Heatherton TF, Wagner DD (2011) Cognitive neuroscience of self-regulation failure. Trends Cogn Sci, 15:132–139.

Hornsey MJ, Harris EA, Bain PG, Fielding KS (2016) Meta-analyses of the determinants and outcomes of belief in climate change. Nat Clim Change, 6:622-626.

Jimura K, Chushak MS, Westbrook A, Braver TS (2017) Intertemporal decision-making involves prefrontal control mechanisms associated with working memory. Cereb Cortex, 28:1105-1116.

Kahn PH Jr, Lourenco O (2002) Water, air, fire, and earth:a developmental study in Portugal of environmental moral reasoning. Environ Behav, 34:405-430.

Karimi S, Liobikienė G, Saadi H, Sepahvand F (2021) The influence of media usage on Iranian students' pro-envi-ronmental behaviors: an application of the extended theory of planned behavior. Sustainability, 13:8299.

Karpiak CP, Baril GL (2008) Moral reasoning and concern for the environment. J Environ Psychol, 28:203-208.

Kennedy EH, Beckley TM, McFarlane BL, Nadeau S (2009) Why we don't "walk the talk": understanding the environmental values/behavior gap in Canada. Hum Ecol Rev, 16:151–160.

Klingberg T (2010) Training and plasticity of working memory. Trends Cogn Sci, 14:317-24.

Kohlberg L (1973) Stages and aging in moral development-some speculations. Gerontologist, 13:497-502.

Kollmuss A, Agyeman J (2002) Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior? Environ Educ Res, 8:239–260.

Kortenkamp KV, Moore CF (2001) Ecocentrism and anthropocentrism: moral reasoning about ecological commons dilemmas. J Environ Psychol, 21:261-272.

Lange F, Dewitte S (2019) Measuring pro-environmental behavior: review and recommendations. J Environ Psychol, 63:92-100.

Langenbach BP, Berger S, Baumgartner T, Knoch D (2019) Cognitive resources moderate the relationship between pro-environmental attitudes and green behavior. Environ Behav, 52:979–995.

Lee EJ, Kwon G, Shin HJ, Yang S, Lee S, Suh M (2014) The spell of green: can frontal EEG activations identify green consumers? J Bus Ethics, 122:511–521.

Lehman B, Thompson J, Davis S, Carlson JM (2019) Affective images of climate change. Front Psychol, 10:960.

Mohiuddin M, al Mamun A, Syed F, Mehedi Masud M, Su Z (2018) Environmental knowledge, awareness, and business school students' intentions to purchase green vehicles in emerging countries. Sustainability, 10:1534.

Nielsen KS (2017)From prediction to process: a self-regulation account of environmental behavior change. J Environ Psychol, 51:189–198.

Nordlund AM, Garvill J (2002) Value structures behind proenvironmental behavior. Environ Behav, 34:740–756.

Ockwell D, Whitmarsh L, O'Neill S (2009) Reorienting climate change communication for effective mitigation.Forcing people to be green or fostering grass-roots engagement? Sci Commun, 30:305-323.

Odou P, Schill M (2020) How anticipated emotions shape behavioral intentions to fight climate change. J Bus Res, 121:243-253.

Ramsey JM, Hungerford HR, Volk TL (2017) Environmental education in the K-12 cirriculum: finding a niche. J Environ Educ, 23:35-45.

Redondo I, Puelles M (2016) The connection between environmental attitude-behavior gap and other individual inconsistencies: a call for strengthening self-control. Int Res Geogr Environ Educ, 26:107–120.

Rees J, Klug S, Bamberg S (2014) Guilty conscience: motivating pro-environmental behavior by inducing negative moral emotions. Clim Change, 130:439-452.

Rezvani Z, Jansson J, Bengtsson M (2017) Cause i'll feel good! an investigation into the effects of anticipated emotions and personal moral norms on consumer pro-environmental behavior. J Promot Manag, 23:163–183.

Krebs RM, Prével A, Hall JM, Hoofs V (2023) Think green: investing cognitive effort for a pro-environmental cause. J Environ Psychol, 85:101946.

Sawe N, Knutson B (2015) Neural valuation of environmental resources. NeuroImage, 122:87–95.

Schneider CR, Zaval L, Markowitz EM (2021) Positive emotions and climate change. Curr Opin Behav Sci, 42:114–120.

Schultz PW (2000) Empathizing with nature: the effects of perspective taking on concern for environmental issues. J Soc Issues, 56:391–406.

Shamay-Tsoory S (2015) The neuropsychology of empathy: evidence from lesion studies. Rev Neuropsychol, 7:237-243.

Summerfield C, Mangels JA (2005) Coherent theta-band EEG activity predicts item-context binding during encoding. Neuroimage, 24:692-70.

Steg L, Vlek C (2009). Encouraging pro-environmental behaviour:an integrative review and research agenda. J Environ Psychol, 29:309–317.

Steg L, Bolderdijk JW, Keizer K, Perlaviciute G (2014a) An integrated framework for encouraging pro-environmental behaviour: the role of values, situational factors and goals. J Environ Psychol, 38:104–115.

Steg L, Perlaviciute G, van der Werff E, Lurvink J (2014b) The significance of hedonic values for environmentally relevant attitudes, preferences, and actions. Environ Behav, 46:163–192.

Steinbeis N, Crone EA (2016) The link between cognitive control and decision-making across child and adolescent development. Curr Opin Behav Sci, 10:28-32.

Stern PC (1992). Psychological dimensions of global environmental change. Annu Rev Psychol, 43:269-302.

Stern PC, Dietz T, Kalof L (1993) Value orientations, gender, and environmental concern. Environ Behav, 25:322–348.

Stern PC (2000) Psychology and the science of human-environment interactions. Am Psychol, 55:523–530.

Swim JK, Clayton S, Howard GS (2011) Human behavioral contributions to climate change: psychological and contextual drivers. Am Psychol, 66:251-264.

Şandor S, Gürvit İH (2019). Development of somatic markers guiding decision-making along adolescence. Int J Psychophysiol, 137:82-91.

Tapia-Fonllem C, Corral-Verdugo V, Fraijo-Sing B, Durón-Ramos MF (2013) Assessing sustainable behavior and its correlates: a measure of pro-ecological, frugal, altruistic andequitable actions. Sustainability, 5:711-723.

Thompson SCG, Barton MA (1994) Ecocentric and anthropocentric attitudes toward the environment. J Environ Psychol, 14:149-157.

Tuncay-Yuksel B, Yılmaz-Tüzün Ö, Tuncer-Teksoz G (2011) The relationship between environmental moral reasoning and environmental attitudes of pre-service science teachers. Int Electron J Environ Edu, 1:167-178.

Verplanken B, Whitmarsh L (2021) Habit and climate change. Curr Opin Behav Sci, 42:42–46.

Wilson EO (1988) The current state of biological diversity. In Biodiversity (Eds EO Wilson, FM Peter):3-18. Washington, National Academy Press.

Wyss AM, Knoch D, Berger S (2022) When and how pro-environmental attitudes turn into behavior:the role of costs, benefits, and self-control. J Environ Psychol, 79:101748.

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