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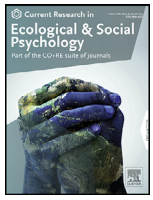

Implicit association test (IAT) toward climate change: A PRISMA systematic review

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ABSTRACT

Global environmental concerns affecting our planet require immediate action. To better understand the psychological dynamics underlying the adoption of pro-environmental behaviors, research increasingly directed its attention to the implicit (unconscious) psychological antecedents (attitudes) of the adoption of sustainable behaviors against climate change. The objective of this systematic review was to examine and summarize the current evidence for the association between the implicit attitudes related to climate change measured through the Implicit Association Test (IAT), and the explicit attitudes, beliefs, and identity toward climate change. Based on PRISMA guidelines, a structured electronic literature search of Google Scholar, PsycInfo, PubMed, Science Direct, PsycArticles, Sociological Abstracts, and Academic Search Complete was conducted. Of the 943 abstracts screened, only 18 studies met the inclusion criteria. Most studies testified independence between implicit and explicit attitudes towards climate change (absence of correlation). Despite this, implicit attitudes still predicted pro-environmental identity, while contradictory results appeared with beliefs. This highlights the urgency of promoting new research to understand on a deeper level dynamics involving implicit attitudes.

1. Introduction

The drastic changes affecting our planet imposes an adaptive imperative: communities, indeed entire societies, must become more resilient in response to these changes (Hodgson, 2010). The behaviors and lifestyles of individuals, communities, and society play an important role in explaining global environmental threats (e.g., climate change, biodiversity decline, deforestation; Allen et al., 2018, IPCC, 2018; Laffoley and Baxter, 2016).

Global environmental threats require immediate action to significantly mitigate the negative impacts of climate change (IPCC, 2018). For this reason, European Green Deal areas, from climate action to zero pollution, require a change in social and behavioral practices by individuals as well as communities and public and private organisations. Although these transformative practices are scientifically proved (Stern, 2006) and institutionally and politically advanced, people do not perceive them as urgent because the effects of these actions are not immediately reversible (Bettie, 2010) and climate change is an abstract concept that is difficult to grasp (Markowitz and Shariff, 2012; Moser, 2010).

As reported in a number of studies (Clayton and Brook, 2005; Swim et al., 2011), there is a need to focus simultaneously on understanding and promoting individual-level behaviours that reduce unsustainable impacts on the natural environment.

Researchers have long sought to understand what factors can influence the persuasiveness of communication in marketing and public information campaigns to promote behavior change that leads to environmentally friendly outcomes (Cismaru et al., 2011; Hall and Taplin, 2007; Kidd et al., 2019; Markelj, 2009; Nelson et al., 2011). Several variables have been identified, including demographic variables, knowledge and education, values and ideologies, political orientation, and psychological factors (Guy et al., 2014; Hart et al., 2015; Weber, 2016; Whitmarsh, 2011). The latter have been the most studied in the context of climate change, as they are the most susceptible to intervention (Hornsey et al., 2016). Among these studies, environmental identity is highlighted, defined by Clayton (2003) as "a sense of connection to the natural environment that influences the way we perceive and behave toward the world." As indicated by a number of studies in this direction, the correlation between people with a strong environmental identity and pro-environmental behavior seems to be high (Schultz, 2002). Another important factor highlighted in the literature that may have an impact on individuals' behavior change is their beliefs (Beattie and McGuire, 2012). Previous studies have found a relationship between beliefs about climate change and specific knowledge about climate change (i.e., those who were knowledgeable about the causes and health consequences of climate change rated climate change as riskier than those who were less knowledgeable; Guy et al., 2014; Sundblad et al., 2007).

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Psychological distance in relation to climate change is another factor that has been explored in the literature with a wide range of variables including "concern," "engagement" "motivation," "intention," and "willingness" to act. Studies suggest that lower psychological distance may promote concern and willingness to act (Manning et al., 2018). Although the aforementioned factors have been studied extensively in the literature, attitudes towards climate change have been the most commonly studied. In the field of climate change research, understanding people's attitudes toward the environment is a crucial issue. Allport introduced the definition of "attitude" in 1935 as "a mental and neural state of readiness, organized by experience, and which exerts a directive or dynamic influence on the individual's response to all objects and situations with which it is associated". In summary, an attitude is a state of mind that influences people's behavior. Psychology distinguishes between two different types of attitude: explicit and implicit. Explicit attitudes are a person's conscious concepts that people are fully aware of, which are traditionally measured using a self-report survey (i.e., measures based on several items), feeling thermometers (i.e., thermometer-like scales to measure a feeling towards a particular attitude object) or semantic differentials (i.e., ratings of basic evaluative dimensions toward a given attitude object; Hofmann et al., 2005; Songa et al., 2018). Implicit attitudes are referred to as automatic evaluations that occur without conscious awareness, including the automatic effect that they have on behaviors and thoughts (Greenwald and Nosek, 2008; Prestwich et al., 2008; Songa et al., 2018) and can be assessed using indirect methods: the Affective Priming Test (Fazio et al., 1986); the Implicit Association Test (IAT) (Greenwald et al., 1998); and the Affect Misattribution Procedure (AMP) (Payne et al., 2008).

Implicit attitudes were assessed using a version of the Implicit Association Test (Greenwald et al., 1998). According to the APE (Associative-Propositional Evaluation) model, such attitudes, which are not always in the same direction, exist simultaneously in the individual and can influence each other (Gawronski and Bodenhausen, 2006). For this reason, it is important to measure them independently and to consider their interaction in order to achieve a long-term effects of behavioural change.

The decision to examine implicit attitudes in sustainability-related domains is based on a large literature that conceptualises them as more enduring than explicit attitudes (Wilson et al., 2000; Greenwald and Banaji, 1995). Implicit attitudes have been found to be associated with pro-environmental behavior, investor decisions, and people's choices regarding brand selection, recycling behaviors, and sustainability actions (Steiner et al., 2018). Specifically, implicit attitudes were statistically significantly related to explicit attitudes towards climate change (O'Donnel et al., 2020; O'Donnel et al., 2021), climate change beliefs (i.e., environmental values; Thomas and Walker, 2016, Rudman et al., 2013), and pro-environmental identity (Wang et al., 2016; Thomas and Walker, 2016; Brick and Lai, 2018). This research shows that implicit attitudes combined with explicit measures provide a more comprehensive understanding of how people act in the field of sustainability (e.g., perceptions of renewable energy) and become more predictive of some types of behaviors than others (i.e., pro-environmental identity; biosphere-related environmental concern, and altruistic environmental concern) (Truelove et al., 2014; Thomas and Walker, 2016; Brick and Lai, 2018; Schultz and Tabanico, 2007). Given that attitudes toward sustainability are sensitive to socially desirable responses (Maass et colleagues, 2000), IAT measures that automatically activate associations appear to be particularly advantageous (Brick and Lai, 2018; McGuire and Beattie, 2019).

The IAT is a computer-based task that measures the strength of association between pairs of concepts using 4 different groups of pictures or words (i.e., targets) presented on the screen (Lane et al., 2007). Participants must quickly classify the individual stimuli in each category and match them to one of two possible responses. The underlying assumption is that the response will be easier, and therefore faster and more accurate if the associated categories share the response. If two concepts are highly associated the task will be easier if they have the same response than if they have different responses (Lane et al.,2007). For example, people with implicit biases, will respond more slowly when an unpleasant category and a pleasant attribute share the same response than in the opposite configuration. The difference in the latency of the response to a particular concept and attribute pairing compared to another provides an index of the strength of the association between the two pairings; the speed of response reflects a different implicit attitude. Since its beginnings, several studies have suggested that the IAT is a valid and reliable measure of implicit attitudes (Cunningham et al., 2001; Greenwald and Nosek, 2001).

For this reason, we decided to address a systematic review in order to obtain a map of the relationship between implicit attitudes and a range of explicit measures.

2. Material and methods

2.1. Search and selection strategy

This systematic review was carried out through the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines. As a first step, we proceeded to search for scientific studies about the "Implicit association test" and "Climate change". The author consulted the databases of Google Scholar, PsycInfo, PubMed, Science Direct, PsycArticles, Sociological Abstracts, and Academic Search Complete. Search terms were the following: "implicit association test" and "climate change" (1100 sources), "implicit association task" and "climate change" (44 sources).

Inclusion Criteria: The inclusion criteria were (i) publication date until March 2022, (ii) being an empirical study, master's thesis, or project report, and (iii) written in English or Italian languages, which are the languages known by the authors, (iv) published in a scholarly peer-reviewed journal or conference proceedings, (v) assessing the relationship between implicit attitudes measured with IAT and with measures related to climate change (i) explicit attitudes, (ii) beliefs related to climate change, (iii) pro-environmental identity, (iv) emotion.

In this systematic review, all the studies measured implicit attitudes related to climate change through the implicit association test (IAT).

Pre-exclusion Criteria: Final records identified through database searching were 1144. Among these, 200 records were excluded due to the fact that they were books, book chapters, citations, dissertations, letters, editorials, or comments.

Exclusion Criteria: Among these 735 works, 716 were excluded based on the following exclusion criteria: (i) the research did not explore the relationship between the constructs mentioned (i.e., absence of univariate statistical relationships between the constructs of interest); (ii) data analysis was not suitable for the systematic review process (e.g., lack of descriptive statistics, no correlation coefficients provided for the variables of interest); (iii) works written in languages other than English or Italian; (iv) did not use Implicit Association Test (IAT) for the measurement of implicit attitudes related to climate change, (v) works that resulted as in progress in March 2022 (thus were not concluded).

3. Results

3.1. Characteristics of the studies

The 17 studies included in this systematic review were cross-sectional studies assessing the relationship between implicit attitudes related to climate change through the implicit association test (IAT) and climate change-related measures (explicit attitudes toward climate change, attitudes toward sustainability, and recyclability, climate change beliefs, environmentalist identity, and pro-environmental concern). The studies included in this systematic review follow a particular geographical distribution: the research focused mainly on Europe such as the United Kingdom (7), Germany (3), Switzerland (1), and Belgium

(1), followed by other studies in North America like the USA (4), Canada (1). Only one study from Eastern Asia was included such as China (1).

The included studies show a rather variable sample age distribution: due to the sampling techniques used by most of the research designs conducted in this research area, it is possible to introduce a sample bias that may affect their representativeness. However, among the studies included in this systematic review, clusters can be identified in termis of the characteristics of the sample age of the studies. The first cluster, consisting of 11 studies, includes studies that examined the relationship within a specific population with a sample of Generation Y young people aged 18 to 35 years old. Generation Y, along with the previous generation cohort, i.e. Generation X, has been identified as more active and environmentally conscious than previous generations. The second cluster, consisting of 11 papers, includes studies that, despite a wider age range of the sample, have a relatively high proportion of middle-aged people, although these studies do not specifically target this population. The third cluster, which includes only 2 studies in this review, contains a study conducted with a specific target group, which is undergraduate students. The last cluster consisting of 4 studies, consists of research that does not provide enough information to derive a distribution of the sample used to conduct the research.

Of the 17 studies considered, 8 referred to the classic version of the implicit association test (IAT) developed by Greenwald et al. (1998). 3 studies used a single-item category SC-IAT (Karpinski and Steinman, 2006), which measures the strength of evaluative associations with a single attitude. Menzel et al. (2021), for example, chose this test variant to separately measure the different dependent variables they used in their study without the need for a contrasting category. 2 studies used a short version of the Implicit Association Test, namely the ST-IAT (Bluemke and Frieses, 2008), which consists of five blocks (20 trials in the first block, 48 trials in the other blocks), and the Brief IAT (BIAT; Sriram and Greenwald, 2009), which allows comparison of multiple categories to assess implicit attitudes and was preferred by the authors because there were four different categories in their work, so they opted for a shorter form (Truelove et al., 2014).

One study used the Go/No-go Association Test (GNAT; Nosek and Banaji, 2001), which measures implicit associations between two categories (Go) and not with others (No-Go). The GNAT was chosen for two reasons. First, because it allows problems to be assessed in a context-free manner (Spence and Townsend 2006), meaning that judgments about a particular implicit social cognition can be made independently of other complementary of contrast categories (Nosek and Banaji, 2001). Second, the GNAT format was appropriate for examining authors' study of heuristic thinking (Townsend et al., 2014). 3 studies used the Carbon Footprint implicit association test (Bettie, 2010; Bettie & Sale 2009, Bettie & Sale 2011, Bettie & McGuire 2012, 2016), a specific version based on the IAT (Greenwald et al., 1998) and designed to test individuals' implicit attitudes toward target categories (high/low carbon) by measuring the associative link between them and attribute categories (good/bad). A study adapted from Greenwald et al. (1998) and Beattie and McGuire (2012) the Environmental Attitudes IAT, a computerized indirect measure of the relative strength of positive and negative associations related to the environment, one study used the Environment IAT (Thomas and Walker, 2016), a validated measure of people's implicit biospheric values, and finally one study used the Sustainability IAT to assess the implicit association between sustainability and positive feelings.

To assign each IAT-experience to a specific cluster, we relied on a strict protocol. Expert psychologists (two in climate change related attitudes, one in pro-environmental behavior, and two in environmental psychology) were asked to independently identify clusters related to IAT target category. Subsequently, each IAT-based experiment was shunted into one cluster rather than another according to the description that the article authors provided. Eventually, they were asked to debate any points of potential disagreement until, after careful consideration, reaching unanimity.

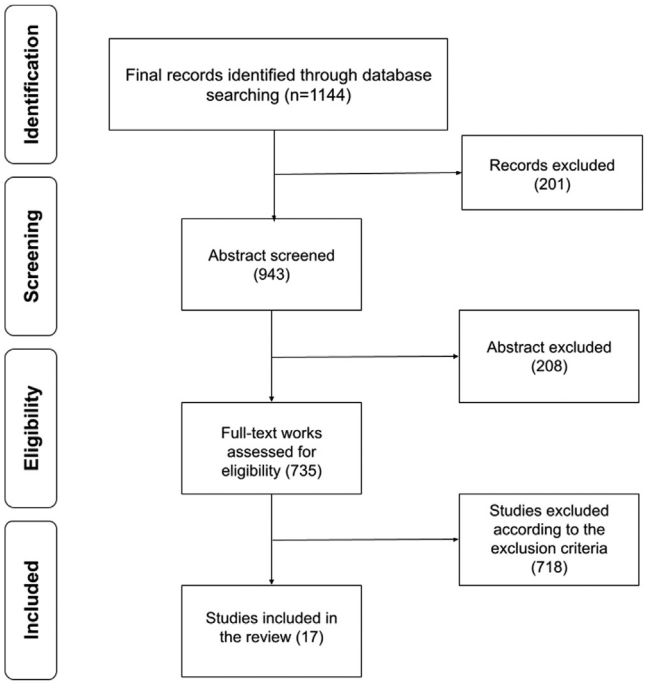

Fig. 1. Diagram showing the information flow through the review: the number of records identified, included, and excluded.

The studies included in this review can also be clustered based on the IAT target category (i.e., attributes) (Fig. 3): 9 studies used target attributes to refer to *attitudes toward sustainability,* of which one focused on the use of plastics and one on recyclability and 3 studies used target attributes related to *renewable energy* (e.g., nuclear power, coal, natural gas, and wind energy).

Attitudes toward climate change were assessed by 3 studies, one of which focused on eco- friendliness of products (e.g., "eco- friendly/not eco- friendly") and another of which focused on implicit attitudes towards supportive/unsupportive policies designed to combat climate change. Two studies assess the climate change beliefs, one used "environmentalist/self" and "environmentalist/other" targets to assess environmental identity. For the sake of clarity and since Attitudes toward Climate Change, Attitudes toward Sustainability, and Renewable energy clusters might be ambiguous in their distinctiveness, we specify the following. Were included into the Attitudes toward Climate Change cluster those works that used the wording "climate change" within the IAT (e.g., supportive of policies designed to combat climate change). Into the Attitudes toward Sustainability cluster were included studies that aimed to measure sustainability behaviours (e.g. preference to purchase low/high carbon impact items), while in Renewable Energy cluster studies were added that analyzed attitudes toward renewable energy (i.e., the attributes mentioned in the studies were: Nuclear, Coal, Natural Gas, Wind, and Photovoltaic), which produced a quite homogeneous pool of works, that the experts decided to keep separate from both Sustainability and Climate Change clusters.

Another clustering, following a similar strict protocol, can be conducted on the basis of the dependent variable assessed. More specifically the constructs studied were identified based on the instruments used to measure DVs. These constructs were then compared and grouped by similarity. Through special focus group meetings, the experts arrived at the formation of three clusters, which were: explicit attitudes toward climate change, climate change beliefs, and environmentalist identity. Among 17 studies, one of the most used dependent variables was *explicit attitudes toward climate change*, which was present in 6 of the cases. The dependent variables within this cluster were all measured with ad-hoc

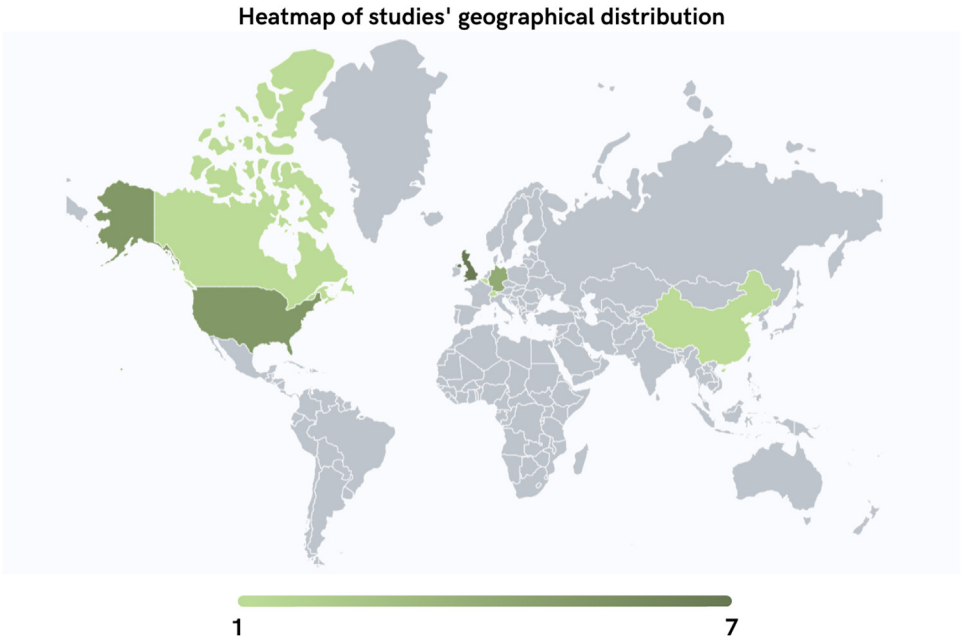

Fig. 2. - Heatmap of the studies assessing the relationship between implicit attitudes related to climate change through the implicit association test (IAT) and climate change-related measures included in our systematic review ($N = 17$).

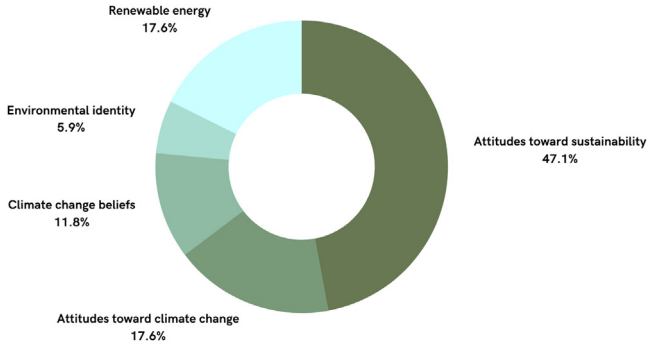

Fig. 3. Clustering of the IAT target category included in the systematic review.

instruments assessing explicit attitudes toward climate change except for one that used the TPAH task by Finucane et al., 2000. The second most used dependent variables was *attitudes toward sustainability and recyclability* examined in 6 studies, which used ad hoc instruments (e.g. "Attitude toward sustainability" with subdimension "Economic, Ecological, Social, Institutional, Cultural"; Steiner et al., 2018). *Climate change beliefs* was the third dependent variable used with 3 studies. For example, within this cluster was included a study that measured beliefs towards climate change (e.g., the belief that climate change is anthropogenic) assessed with the New Environmental Paradigm (NEP; Dunlap, Van Liere, Mertig, & Jones, 2000). The last cluster was composed by *environmentalist identity* in two papers respectively measured with *Inclusion of Nature in the Self Scale* (INS)(Schultz, 2002) and *Explicit environmentalist identity* (Brick et al., 2017; Smith, Seger, & Mackie, 2007; Schultz, 2002)

3.2. Study results

The results of the following studies included in the review were clustered based on the purpose of the study. Through this analysis, it was possible to identify 3 clusters through which the implicit attitudes were related: implicit vs explicit attitudes, implicit vs emotions, implicit vs climate change beliefs, and implicit vs environmentalist identity. In order to establish the effect size of the relationship, 16 studies included in this systematic review used correlation as a method of analysis, 1 used multiple linear regression analysis, and 1 used ANOVA.

3.2.1. Implicit vs explicit attitudes

In this cluster, we refer to implicit attitudes associated with explicit attitudes (i.e., explicit attitudes about climate change and sustainability and recyclability). Among these studies, the results for 8 studies show a correlation close to zero, while 5 studies found a positive relationship.

3.2.2. Implicit vs climate change beliefs

For this cluster, the results between climate change beliefs and implicit attitudes showed a weak correlation for one study, a non-significant relationship for two studies, while for one study the relationship was negative but statistically significant the first time and positive and statistically significant the second time due to an extreme weather event exposure.

3.2.3. Implicit vs environmentalist identity

Finally, regarding the studies that assessed implicit attitudes in relation to environmental identity, one of them found a positive and statistically significant relationship, while another found only a moderate but statistical relationship.

3.3. Risk of bias

Table 2 shows the main risks of bias within the selected reports. Almost all studies included in this systematic review used nonprobability sampling methods. All studies presented possible sampling bias due to the low representativeness of the sample. Of the included studies, two gathered responses from residents of the area where the study was conducted, while seven only contacted students through university channels (e.g., e-learning platform, newsletters), and only one exclusively targeted professional Swiss energy investment decision makers. Furthermore, 5 studies used online surveys (through social networks, e-mails, or other internet-based means) to reach respondents, meaning that people who did not have access to the internet could not fill in the questionnaire: in developing countries, this may increase the likelihood of sampling bias, due to the fact that a big portion of the population still doesn't have access to the internet. Besides, all of the studies used small sample

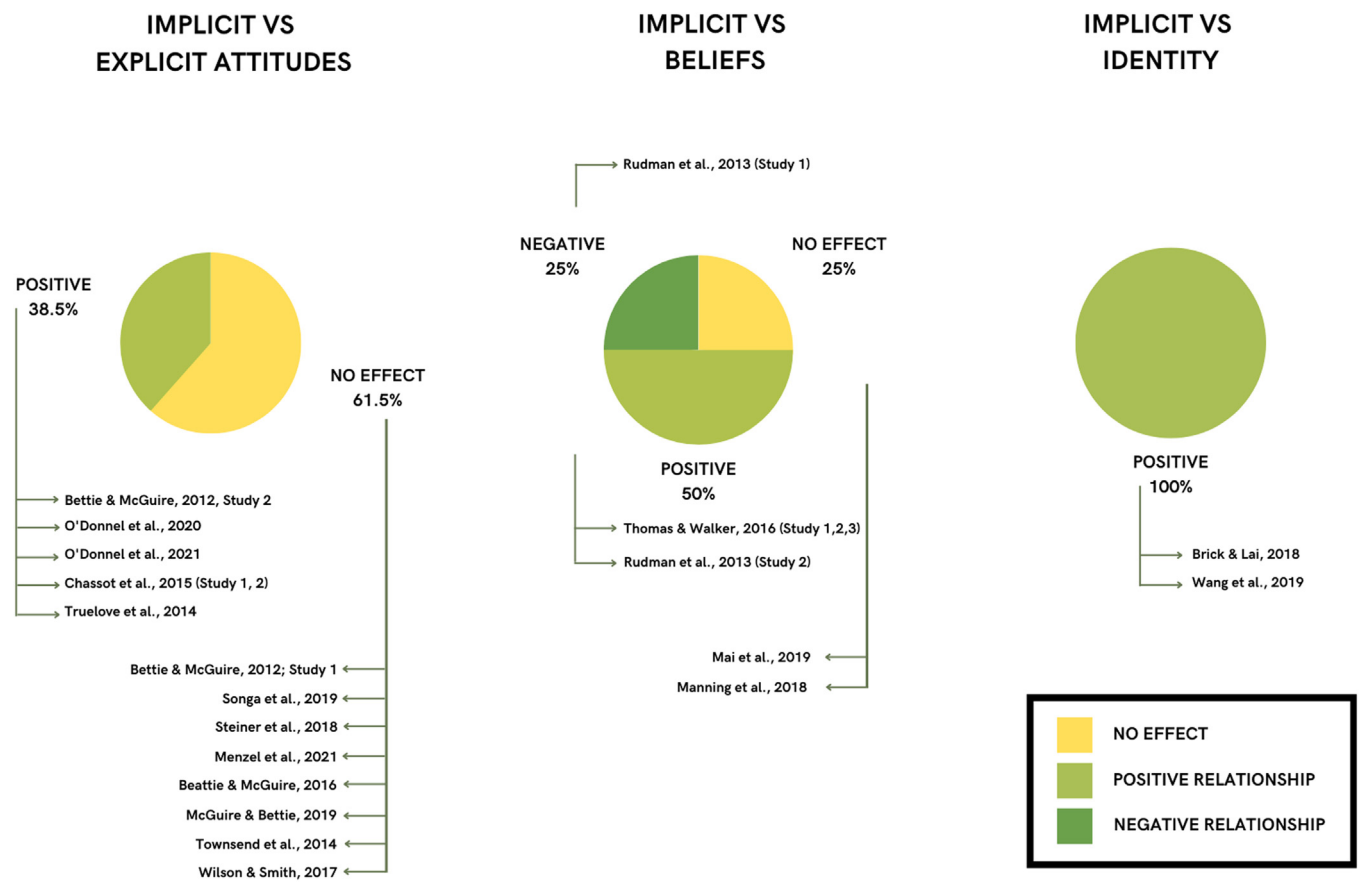

Fig. 4. In the figure is reported a three clusters categorization of the studies considered by the present systematic review. For each cluster, the number of studies reporting a positive association (light green), a negative association (deep green), or the absence of a statistical effect (yellow) between the variables are summarized and graphically represented.

sizes, thus low representativeness and possible type II errors could not be excluded. Moreover, 2 studies did not report data about the characteristics of the sample, while 2 studies reported a low response rate, meaning that a self-selection bias could not be excluded. Additionally, two studies present bias due to the impairment of the online IAT implicit score, in particular in O'Donnell et al. (2021) due to internet speeds, computer specifications, and distractions, while in Thomas & Walker (2016), due to environmental experience (i.e., music, disturbances, the uncertainty of test parameters).

4. Discussions

In this study, a literature review was conducted to determine the current status of assessing implicit attitudes towards climate change using the implicit association test (IAT). Overall, the majority of studies included in this review (i.e., Bettie & McGuire, 2012; Bettie & McGuire, 2016; McGuire & Bettie, 2019; Menzel et al., 2021; Songa et al., 2019; Steiner et al., 2018; Townsend et al., 2014; Wilson and Smith, 2017) reported a non-significant association between climate change IAT scores (implicit attitudes) and explicit climate change attitudes assessed using traditional tools. Consistent with the Dual Attitudes Model (Devine, 1989; Wilson et al., 2000) and the MODE Model (Fazio, 1990; Fazio et al., 1982; Fazio and Towles-Schwen, 1999), implicit and explicit attitudes may not be related (Fazio and Olson, 2003; Echabe, 2013). This kind of independence was also found in our included studies on the topic of climate change topic. More specifically, findings revealed that self-report attitudes (explicit) and implicit attitudes (IAT) towards climate change did not correlate for what concern "*low/high carbon products*" (Beattie and McGuire, 2016), "*recycling*" (Songa et al., 2019), "*sustainability*" (Steiner et al., 2018), or "*plastic*" (Menzel et al., 2021). Notably, only 5/18 works showed a significant positive relationship between implicit and explicit attitudes (O'Donnel et al., 2020; O'Donnel et al., 2021). Given the contrasting evidence outlined above, and the role that both explicit (Brick and Lai, 2018) and implicit (McGuire and Beattie, 2019) attitudes appear to play in predicting sustainability behavior, it is recommended that both of these indicators be considered in order to model it.

Regarding the relationship between the IAT and climate change beliefs, Thomas & Walker (2016) found a positive correlation between implicit attitudes toward climate change and explicit measures of environmental values, and climate change beliefs. Rudman and colleagues (2013), reported that the relationship between implicit attitudes and climate change beliefs shifted from a negative (small) coefficient to a positive (small) coefficient after a direct experience of extreme weather. In contrast, the findings of Mai and colleagues (2019) showed that the relation between implicit attitudes and climate change beliefs is null in the case of belief that sustainability is associated with less product quality.

For what concerns identity, the positive correlations between implicit attitudes towards climate change and the "explicit environmentalist identity" (Brick et al., 2017; Smith, Seger, & Mackie, 2007; Schultz, 2002)" reported by Brick and Lai (2018) and with the "Inclusion of Nature in the Self Scale" (Schultz, 2002) by Wang (2019), and with the explicit measures of environmental values by Thomas & Walker (2016) testify how implicit attitudes capture some of the fundamental aspects of pro-environmental identity. Indeed, the IAT seems to be positively associated with pro-environmental identity val-

ues as demonstrated by studies of Wang et al. (2016); Thomas & Walker (2016), and Brick & Lai (2018). However, people who integrate nature into their self-definition appear to have a greater implicit connection with nature, which is positively correlated with biosphere-related environmental concerns and altruistic environmental concerns (Schultz and Tabanico, 2007)

Overall, the observed heterogeneity of the results confirms the scientific scenario of low correlations between implicit and explicit measures, which are low across domains (Cameron et al., 2012; Greenwald et al., 2009; Hofmann et al., 2005). Theoretically, the strength of the correlation may vary due to lack of introspective access to implicitly assessed representations (Nosek, 2005), motivational biases in explicit self-reports, factors influencing the retrieval of information from memory, method-related characteristics of the two measures, or complete independence of the underlying constructs (Hofmann et al., 2005). Nevertheless, it is essential to understand the potential differences between deliberate and slow responses in compared to a fast and automatic evaluation in order to identify the discrepancy between problem awareness and behavior (Menzel et al., 2021). Although many researchers attribute this discrepancy to different approaches to measurement or to the dynamics of response bias, it is quite possible that climate change issues may be one of those domains in which explicit and implicit attitudes can be "dissociated" as suggested by Greenwald and Nosek (2008). Indeed, the association between implicit and explicit measures seems to emerge in the case of "trivial, socially uncontroversial objects" (Dovidio and Fazio 1992; Fazio and Olson 2003). Climate change has peculiar characteristics compared to other domains (Bettie & McGuire, 2016) in terms of the problem perception and difficulty of the issue (Hansen et al., 2013), the social inertia caused by the " global response" required to operate on the issue (Walker and King, 2008), the negative emotional valence of the issue that generates avoidance (Ehrenreich, 2009). These characteristics may generate the observed inconsistency between implicit and explicit components (i.e., attitudes, values, beliefs), in line with the MODE model (Fazio, 1990; Fazio et al., 1982; Fazioand Towles-Schwen,1999).

5. Conclusions

In summary, the IAT appears to maintain relationships with explicit attitudes (e.g., "low-carbon/high-carbon products" (Beattie and McGuire, 2016), "recycling" (Songa et al., 2019), "sustainability" (Steiner et al., 2018), or "plastics" (Menzel et al., 2021) and beliefs (Mai et al., 2019) that are often inconsistent in terms of direction and magnitude of effect. Nonetheless, the association between implicit attitudes and (environmental) identity appeared to be positive and consistent across the included studies (i.e., identity; Brick and Lai, 2018, Wang et al., 2019). The heterogeneity observed across studies can be attributed to the inherent dynamics of the measurement methodology as well as the specific topic of climate change, which has specific idiosyncrasies compared to topics such as ingroup prejudice (Greenwald et al., 1998; Kuehnen, et al. 2001; Rudman et al., 1999) or racism (Nosek et al., 2002).

Declaration of Competing Interest

No conflict of interest has been declared by the authors.

Data availability

No data was used for the research described in the article.

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Appendix

Table 1

Table 1
Main characteristics of the studies reviewed: reference, sample size, gender distribution, age mean/age distribution, country, service type, independent variable, dependent variable, presence of gamification and results (n = 113).

Ref.	Sample size	Gender distribution	Age mean / age distribution	Country	IAT type	Dependent variables	Results
Wang, J., et al. 2019	103	58,25% M 41,75% F	17–29: 21,43	China	SC-IAT (Karpinski and Steinman, 2006)	Inclusion of Nature in the Self Scale (INS)(Schultz, 2002)	$\beta(1) = 0.51$
Beattie and McGuire 2012	180	nr	nr	UK	IAT (Greenwald et al., 1998)	Explicit attitude test: (1) Likert scale (2) Feeeling termomether	r (1) = −0.013 r (2) = 0.006
Rudman et al., 2013 Studio Time 1	269	46.84% M 53,16% F	18.73	NJ	The Candidate IAT	New Environmental Paradigm (NEP; Dunlap, Van Liere, Mertig, & Jones, 2000)	$r = -0.10$, $p = .09$
Rudman et al., 2013 Studio Time 2	316	51,8 M 48.2 F	18.9	NJ	The Candidate IAT	New Environmental Paradigm (NEP; Dunlap, Van Liere, Mertig, & Jones, 2000)	$r = 0.14$, $p = .01$
O'Donnell et al., 2020	193	nr	nr	UK	IAT (Greenwald et al., 1998).	Explicit test: feeling thermometer	$r = 0.26$, $p = .00$
O'Donnell et al., 2021	41	nr	nr	UK	IAT (Greenwald et al., 1998).	Explicit test: feeling thermometer	$r = 0.380$, $p = .014$
Beattie, and McGuire, 2016	50	38% M 62% F	27.7; 18–67	UK	"Carbon Footprint" Implicit Association Test (Bettie, 2010; Bettie & Sale 2009, Bettie & McGuire 2012, 2015)	(1) Likert Scale (2) Feeling Thermometer	r(1) = 0.016, ns r (2) = 0.198, ns
Chassot et al., 2015 Study 1	35	nr	43,9	Switzerland	IAT (Greenwald et al., 1998)	Net solar energy investments	$r = 0.30$

(*continued on next page*)

Table 1 (*continued*)

Chassot et al. (2015). Study 2	42	nr	41,2	Switzerland	IAT (Greenwald et al., 1998)	(1) Net solar energy investments (2) Explicit association to solar energy and gas	(1) $r = 0.340$ (2) $r = 0.173$; ns
Truelove et al., 2014	704	68% F 32%	48	USA	Brief IAT (BIAT; Sriram and Greenwald, 2009) (1) IAT:Wind-Nuclear (2)IAT: Gas-Nuclear (3)IAT: Nuclear-coal	Explicit preference for nuclear energy (1)Explicit Nuclear-Wind (2)Explicit:Nuclear-Gas (3)Explicit:Coal-nuclear	(1) $r = 0.26$ (2) $r = 0.23$ (3) $r = 0.34$
Wilson, and Smith, 2017	32	25% M 75% F	19.2; 18–23.5	USA	IAT for environmental attitudes (Greenwald et al., 1998; Beattie and McGuire, 2012)	(1) Explicit Attitude Rating (2) Conscious Report Validity	(1) $r = -0.02$ (2) $r = 0.54$, $p < .001$
McGuire and Beattie, 2019	50	38% M 62% F	18–67	UK	Carbon IAT (McGuire and Beattie 2016) (A $n = 26$)SPIA - Strong positive implicit attitude (A $n = 24$)WIA - Weaker implicit attitudes	Likert scale (explicit preference towards high/low carbon footprint products; Greenwald et al. 2003; Beattie 2010)	F(1)= 2.46; ns
Brick and Lai, 2018 Study 1	586	39% M 61% F	39	USA	ST-IAT (Bluemke and Friese's, 2007)	(1) Explicit environmentalist identity (Brick et al., 2017; Smith, Seger, & Mackie, 2007; Schultz, 2002) (2) Pro-environmental concerns (3) Internal Motivation to appear pro-evinvonmental (4) External motivation to appear pro-environmental	(1) $r = 0.25$; $p \leq 0.001$ (2) $r = 0.28$; $p \leq 0.001$ (3) $r = 0.21$; $p \leq 0.001$ (4) $r = -0.07$; $p \leq 0.05$
Brick and Lai, 2018 Study 2	469	31.3% M 68.7% F	41.5				
Brick and Lai, 2018 Study 3	417	26.4% M 73.6% F	18				
Brick and Lai, 2018 Study 4	561	38.9% M 61.1% F	41.6				
Thomas and Walker, 2016 Study 1	42	21.5 M 78.5 F	19, 7	UK	Environment IAT	(1) New Environmental Paradigm (Dunlap et al., 2009) Value Orientation (De Groot and Steg, 2008) (2) Biospheric Values (3) Egoistic Values (4) Altruistic Values	(1) $r = 0.36$; $p < .05$ (2) $r = 0.48$; $p < .05$ (3) $r = -0.32$; $p < .05$ (4) $r = 0.31$
Thomas and Walker, 2016 Study 2	110	53.6% M 46.4% F	25.7	63% were from the United States, 15% from the United Kingdom, 7% from Canada, 3% each from Australia and the Netherlands; other 12% were from Austria, Mexico, New Zealand, Portugal, Singapore, Sweden, Switzerland	Environment IAT	(1) New Environmental Paradigm (Dunlap et al., 2009) Value Orientation (De Groot and Steg, 2008) (2) Biospheric Vaues (3) Egoistic Values (4) Altruistic Values	(1) $r = 0.28$; $p < .01$ (2) $r = 0.26$; $p < .01$ (3) $r = -0.34$; $p < .05$ (4) $r = 0.24$; $p < .05$
Thomas and Walker, 2016 Study 3	140	30.7 M 69.3% F	29.3	UK	Environment IAT	(1) New Environmental Paradigm (Dunlap et al., 2009) Value Orientation (De Groot and Steg, 2008) (2) Biospheric Vaues (3) Egoistic Values (4) Altruistic Values	(1) $r = 0.28$; $p < .01$ (2) $r = 0.19$; $p < .05$ (3) $r = -0.20$; $p < .05$ (4) $r = 0.09$; $p < .05$

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Table 1 (*continued*)

Steiner et al., 2018	114	63 F 51 M	39.9	Germany	Sustainability IAT	Attitude toward sustainability: (1) Economic (2) Ecological (3) Social (4) Institutional (5) Cultural	 (1) $r = 0.17$ (2) $r = 0.00$ (3) $r = -0.03$ (4) $r = 0.11$ (5) $r = 0.05$
Menzel et al., 2021 Study 1	103	31 M 72 F	30.9; 18–66	Germany	Risk SC-IAT (Karpinski and Steinman, 2006)	Explicit items on valence (1) packaging (2) waste (3) microplastic	 (1) $r = -0.10$ (2) $r = 0.09$ (3) $r = 0.12$
Menzel et al., 2021 Study 2	105	28 M 77 F	31.29; 19–77	Germany	Risk SC-IAT (Karpinski and Steinman, 2006)	Explicit items on risk: (4) packaging (5) waste (6) microplastic	 (1) $r = -0.002$; $p = 1$ (2) $r = 0.06$; $p = 1$ (3) $r = 0.004$; $p = 1$
Mai et al., 2019	126*	56% M 44% F	22.5	Germany	Ethical Less Strong Intuition (ELSI) IAT (Greenwald et al., 1998)	The explicit belief in the ELSI	$r = 0.15$, $p > .05$
Songa et al., 2019	89	33% M 67% F	22; 20–25	Belgium	IAT (Greenwald et al., 1998)	Explicit attitude towards recyclability	r = 0.08, p > .05
Townsend et al., 2014	149	37.7 M 62.3 F	ns	UK	GNAT (Nosek and Banaji 2001)	TPAH task risk and benefit toward nuclear power and climate change (Finucane et al., 2000)	ns

* Of the 126, only 95 completed both tasks. However, the percentages of males and females in the final sample are not available.

Table 2
Main characteristics of the studies reviewed: reference, main findings, study limitations, and risk of biases ($n = 18$).

Ref.	Main Findings	Study Limitations	Risk of Biases
Wang, J., et al. 2019	Statistically significant relationship was found between INS and the SC-IAT D-score	Lack of generalizability due to the small sample and all of the respondents are students. Descriptive statistics are missing. The ecological validity of the study was limited.	Sampling bias due to low representativeness of the sample. Measurement bias due to the "Inclusion of Nature in the Self Scale" that have only one item.
Beattie & McGuire (2012) Study 1	Neither of the explicit measures was significantly correlated with the implicit attitude measure	Lack of generalizability due to a small sample. No details are given about sample recruitment. Descriptive statistics are missing.	Sampling bias due to low representativeness of the sample.
Beattie & McGuire (2012) Study 2	There is a statistical association between implicit attitude and how people focus their attention on iconic images of environmental damage and climate change.	Lack of generalizability due to a small sample. Descriptive statistics are missing.	Sampling bias due to low representativeness of the sample.
Rudman, L. A., et al. (2013) Study 1	A negative correlation was found between candidate IAT and belief in anthropogenic climate change before threatening weather.	Lack of generalizability due to restricted age range. The majority of the respondents voted for a green politician so the sample was skewed toward the liberal side.	Sampling bias due to low representativeness of the sample.
Rudman et al., 2013 Study 2	Candidate IAT scores were better correlated with belief in anthropogenic climate change after the threatening weather.	Lack of generalizability due to restricted age range. The majority of the respondents voted for a green politician so the sample was skewed toward the liberal side.	Sampling bias due to low representativeness of the sample.
O'Donnell et al., 2020	A weak but statistically significant correlation was observed between implicit attitudes toward sustainable drainage system (SuDS) and Feeling Thermometer scores.	Descriptive statistics are missing. The study was addressed exclusively to local residents of the area in which the study was conducted	Sampling bias due to the low representativeness of the sample.
O'Donnell et al., 2021	A degree of agreement between conscious and unconscious attitudes toward Blue-Green infrastructure were identified.	Inability to discern whether respondents have a positive association with one target concept and/or a negative association with the other. Impairment of the online IAT implicit score due to internet speeds, computer specifications, and distractions. Descriptive statistics are missing.	Sampling bias due to low representativeness of the sample. Bias is associated with the design of a feeling thermometer.

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Table 2 (*continued*)

Beattie and McGuire, 2016	The explicit and implicit measures were dissociated (no significant correlation) in this domain: self-report attitudes did not correlate with participants' reports of how "war" or "cold" they felt towards low/high carbon products.	Relatively small sample size. Lack of generability due to the majority of the respondents being females, with an average age being 27.7 and being only students.	Sampling bias due to low representativeness of the sample.
Chassot et al., 2015 Study 1	A relatively high correlation was found between implicit cognition with behavior (energy investments) in the expected direction: The more strongly an investor associates solar photovoltaics with return and gas with risk, the higher his investment in solar energy relative to the gas.	Lack of generalizability due to a small sample. The study was addressed exclusively to professional Swiss energy investment decision-makers.	Measure Bias due to the fact that participants have to install a plug-in on their computer to run the test.
Chassot et al., 2015 Study 2	Implicit cognition had a more strongly correlation with (investor) behavior than explicit cognition.	Lack of generalizability due to a small sample.The study was addressed exclusively to professional Swiss energy investment decision-makers.	Measurement bias due to the fact that the dependent variable test did not capture all possible systematic differences in the amount of capital invested in each asset class
Truelove et al., 2014	The study found a significant correlation with explicit attitudes.	Relatively small sample size.Lack of generalization due to the majority of the respondents being females (68%), with an average age of 48 y.o., with a college degree. Responses were collected through an online survey, so people without access to the internet could not fill in the survey. No data were collected from non-users.	Sampling bias due to low representativeness of the sample.
Wilson and Smith, 2017	The study found a null relationship between implicit attitude and participants' explicit attitude ratings. The conscious report validities reliably predicted implicit environmental attitudes. In other words, stronger pro-environment associations correspond with greater validity of task difficulty awareness during the IAT.	Lack of generalizability due to the small sample and prevalence of women undergraduate students in the sample. mostly between 18 and 23.5.	Sampling bias due to low representativeness of the sample. Measurement bias is due to the fact that the IAT doesn't present a performance measure external to the environmental IAT to demonstrate the hypothesized influence of implicit attitudes on sustainable behavior become available to consciousness.
McGuire and Beattie, 2019	There was a tendency for people with a positive implicit attitude towards low carbon to select more low carbon items, however, this fails to reach significance.	Relatively small sample size. Lack of generalization due to the majority of the respondents being females	Sampling bias due to low representativeness of the sample.
Brick and Lai, 2018	Implicit environmentalist identity is a reliable construct that is moderately and positively related to explicit identity	Lack of generalizability due to a small sample and prevalence of the female in the sample (65%) with an average age of 33 y.o.	Sampling bias due to low representativeness of the sample.
Thomas and Walker, 2016 Study 1	Positive correlation with explicit measures of environmental values and attitudes were found. In particular a negative link to Egoistic values, a positive link to Biospheric values and the NEP, and a non-significant link to Altruistic values.	Lack of generalizability due to the restricted age range and prevalence of females in the samples. The study exclusively addressed undergraduate students. Impairment of the online IAT implicit score due to environmental experience (i.e., music, disturbances, the uncertainty of test parameters).	Sampling bias due to low representativeness of the sample.
Thomas and Walker, 2016 Study 2	A weaker correlation between the Environmental IAT and explicit measures was found. In particular a positive link to Nep and the Altruistic values, a negative link to Egoistic values, and a positive link to Biospheric values.	Lack of generalizability due to a small sample. Impairment of the online IAT implicit score due to environmental experience (i.e., music, disturbances, the uncertainty of test parameters).	Sampling bias due to low representativeness of the sample.
Thomas and Walker, 2016 Study 3	A weaker correlation between the Environmental IAT and explicit measures was found. In particular a positive link to Nep and to Biospheric values, a negative link to Egoistic values, and a non-significant link to Altruistic values.	Lack of generalizability due to a small sample. Impairment of the online IAT implicit score due to environmental experience (i.e., music, disturbances, the uncertainty of test parameters).	Sampling bias due to low representativeness of the sample.
Steiner et al., 2018	Explicit ratings and implicit measures were close to zero.	Relatively small sample size. Lack of generalization due to the majority of the respondents being university students and executives from various companies environment-related, in Austria.	Sampling bias due to low representativeness of the sample.

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Table 2 (*continued*)

Menzel et al., 2021 Study 1 Menzel et al., 2021 Study 2	The implicit and explicit attitudes are not significantly related.	Lack of generalizability due to a majority of the respondents being German female, rather young, and having a high education level.	Sampling bias due to low representativeness of the sample. Measure bias due to SC-IAT items that did not represent only plastic-related images but also context information, which might have biased the response time.
Mai et al., 2019	The explicit and implicit measures of ELSI are not significantly related, so these instruments tap into different facets of the ELSI. In other words, even subjects with weaker explicit ELSI subscribe to the intuition implicitly and in a similar fashion as those who report stronger explicit belief in the ELSI.	The study was limited to undergraduates, so the sample was not representative of the population. The present studies do not address the moderating role of the product category.	Sampling bias due to non-probability sampling technique and low representativeness.
Songa et al., 2019	The implicit measure and explicit attitude toward recycling were not significantly correlated.	The study was addressed to youth (20.25) students in a continental European University in Ghent (Belgium), meaning that most of them had a medium-high or high level of education. Lack of generalizability due to restricted age range. The majority of the respondents were women (67%).	Sampling bias due to low representativeness of the sample. Possible measure bias due to implicit and explicit measures assessed two different concepts.
Townsend et al., 2014	There was no correlation between explicit performance and implicit measure.	Lack of generalizability due to a small sample and the majority of the respondents were female. Descriptive statistics are missing.	Sampling bias due to low representativeness of the sample.

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