

Article

Interplay of Message Frame and Reference Point on Recycled Water Acceptance in Green Community: Evidence from an Eye-Tracking Experiment

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Abstract: Public rejection of recycled water hinders the application of recycled water use projects in green communities. An effective information outreach strategy could help to overcome this obstacle. This study used message frames and reference points as control variables to design experimental materials and conduct eye-movement experiments to determine the effect of different information promotion strategies. The results of the study show that: (1) compared with the loss frame, the gain-framed messages are more effective; (2) self-referencing messages are more suitable for recycled water use promotion than other-referencing messages; (3) message frame (gain vs. loss) and reference point (self vs. others) have an interactive effect on the public's information cognitive behavior; (4) the average duration of fixations for advertising message plays an intermediary role in the path of message frame and reference point jointly influencing the public acceptance. This study provides managerial implications for determining information dissemination strategies for applying recycled water-use projects in green communities.

Keywords: green community; public acceptance; eye-tracking; message frame; information policy



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1. Introduction

Currently, many countries and regions of the world face the issue of water scarcity [1]. This issue hinders economic development and brings instability to the harmony of the earth's ecosystem and human society [2]. Therefore, water conservation has become one of the basic requirements and important evaluation indicators in the process of creating green communities [3]. In addition to traditional means such as the use of water-saving appliances in buildings [4], the utilization of alternative water sources in communities is also considered an effective way to save freshwater by increasing water supply sources [5]. Up to now, rainwater reuse, recycled water use, and desalinated seawater use are the three alternative water options that most cities prioritize when building green communities [6]. Recycled water use has the advantage of being a stable water supply source and not being unaffected by seasonal changes compared to rainwater use.

Moreover, recycled water use is more energy-efficient and environmentally friendly than the use of desalinated seawater [7]. Regardless of these advantages, recycled water use is not widely utilized in green communities compared to the other two options [8]. There are many complex reasons for the phenomenon, among which one of the most prominent is public rejection [9]. Most people perceive recycled water as “from toilet to tap”. Therefore, people psychologically repulse it and find it difficult to accept the use of recycled water for residential purposes [10]. Even though current technology can guarantee

that the produced recycled water is fully compliant with drinking standards [11], the public is still reluctant to accept using recycled water for residential purposes [12]. Therefore, to facilitate a successful promotion of recycled water projects in green communities, effective information dissemination strategies are needed to reduce negative public stereotypes toward recycled water and in turn, increase their willingness to accept recycled water.

Effective information dissemination strategies can improve public perceptions and attitudes toward environmental issues and stimulate environmental awareness and social responsibility [13]. The formation of negative public stereotypes and rejection of recycled water is partly due to information asymmetry and lack of knowledge about recycled water [14]. Therefore, it is vital to effectively inform and educate the public to increase their willingness to accept recycled water and accordingly promote the implementation of recycled water use projects in communities [15]. The adequate and effective disclosure of technical information relating to recycled water and the benefits of using recycled water will help increase public trust in relevant stakeholders (i.e., utility companies) and reduce their perceived risk of recycled water [16]. Although many relevant studies have demonstrated that providing information on recycled water can lead to improved public attitudes toward recycled water [17,18], these studies have often overlooked the importance of how the information is disseminated and presented. The way that information is disseminated and presented can significantly influence people's psychological perceptions and greatly affect their judgments and decisions [19]. An application of appropriate and effective information dissemination strategies can enhance persuasion and achieve twice the result with half the effort [20]. Amongst the studies in this area, few have been conducted on the interaction of message frame and reference point on promoting recycled water use. Stakeholders struggle with finding the right way to convey their messages when they carry out advertising efforts to promote recycled water uses [21]. To minimize the disputes and opposition of the public to the recycled water project and to increase their willingness to accept the recycled water use project, it is not only necessary to directly transmit relevant information to the public but also to consider how to take the best measures in the process of publicity. Advertising information is used to persuade the public, that is, to think about "how to tell" to achieve the best persuasive effect, namely, to reverse the stereotype of the public about recycled water and promote the smooth implementation of recycled water use projects in the community.

Regarding the issue of "how to tell", many scholars have carried out related research on message frames. The use of message frames is a classic advertising messaging strategy. It refers to the persuasive effect of the advertisement on the publicist audience can be influenced by the way the audience's behavior results are described in the advertisement [19]. The message frame includes the gain frame and loss frame. Gain-framed messages emphasize the benefits that can be gained from the use of a product or service; loss-framed messages emphasize the possible negative effects of not using the product or service [20]. However, there is still no consensus as to whether the gain or loss frame is more convincing [22,23]. Moreover, in related studies, most of the messages are constructed based on the "self-gain and loss" of the recipient of advertising information as a reference point, and few scholars construct the framework from the perspective of "others' gain and loss" [24]. Even though people are selfish by nature, and they may mainly consider their own interests when doing things, their social attributes determine that they consider the impact of their behavior on others when making decisions [25]. In fact, the reasons or motivations for a person to actively engage in pro-environmental behavior can be attributed to the following four categories: egoism, collectivism, altruism, and principlism [26]. Egoism and principlism take "self" as a reference point, and actions are made to conform to personal interests or personal moral principles. Collectivism and altruism take "other" as the reference point, and actions are made from consideration for the interest of the collective or others.

The promotion and use of recycled water in the community is a kind of civic responsibility and pro-social behavior. It is not only related to the individual family of the community residents but may also involve the interests of other neighbors and is related

to the progress and development of the community, city, country, and even human beings [27,28]. Researchers have conducted extensive studies on the influence of such factors as the quality of treated recycled water meets the nation's safety standard, public trust in local authorities to ensure the quality of recycled water or effective educational programs for the acceptance of all potential users for using recycled water [6,29–33]. However, it is hardly reaching an agreement among researchers on what impacts public acceptance of recycled water and what information/education outreach strategy could increase public acceptance of recycled water. The exploration is further made complex due to the large difference in population size, values, social and cultural norms, or dwelling types between the eastern and western countries [34].

These previous studies all collected their data via questionnaires or text mining methods, which are subjective and lagging. It is difficult to fully understand individuals' real thoughts and thinking processes when they make decisions from the data of this type [5]. To address the concerns, this study introduced the experimental tool of cognitive neuroscience eye-tracking to the research area and conducted an Eye-tracking experiment to explore the effects of advertising information about recycled water use on public acceptance of recycled water and its underlying mechanisms, in the hope of making contributions to both literature and methodology body in the area. It uses recycled water advertisement posters as the information carrier and employs the method of situational simulation to obtain objective indicators of cognitive neural mechanisms in individual decision-making processes [35,36]. The message frame in recycled water use publicity cannot be limited to the "personal gains and losses" of the information recipients but also needs to explore the persuasive effect on the information audience when taking "the gains and losses of others" as the reference point.

In this paper, we first subdivide the message strategy of promoting recycled water in the community into: on the one hand, it inherits the classical linguistic strategy variables in advertising information research, i.e., the goal framing in the message frame, including the benefits of using recycled water (gain-framed message) and the costs of not using recycled water (loss-framed message); on the other hand, a set of linguistic strategy variables with practical implications are in the message frame: self-referencing or other-referencing (whether a message is described from the perspective of "self" or "others"). The purpose of this paper is to investigate the effects of message frames, reference points, and the interaction between message frames and reference points in the advertising information on recycled water use on the public's willingness to accept recycled water and their underlying mechanisms.

2. Literature Review

2.1. Recycled Water Use in Green Communities

In recent years, with the deepening of the concept of sustainability, the construction of green communities has become the development trend of future cities [37]. The green community is the human habitation that connects the ecological city and the green building [38]. It is the basic component unit of the city and plays an important role in reducing energy consumption [39,40], improving people's living environment, and promoting urban development [41]. At the same time, since the world is facing severe water shortage and water quality deterioration, water conservation is often one of the basic requirements and key evaluation indicators for building green communities [42]. Among them, the construction of recycled water use projects converts the sewage generated by the community into clean water, which is one of the main ways and effective means to achieve water savings by increasing the available water resources in green communities [5].

Green communities are intermediate units and essential players involved in energy conservation, environmental protection, and green city sustainable society construction [38]. People can implement recycled water use measures more effectively and flexibly in green communities [37]. Therefore, the planning, construction, and management of recycled water use projects in green communities are also critical. Some green communities in

Singapore [43], the United States [44], Namibia [45], and Emory University [46] in the Druid Hills suburb outside Atlanta, Georgia, have taken a number of steps to implement recycled water-use projects in their communities or on their campuses, and have achieved significant water-saving effects as expected. At the same time, however, widespread public rejection remains a major obstacle to the implementation of recycled water projects in many other communities [17,47], such as the failed construction of recycled water use projects in Sunshine Coast [48] and Toowoomba [49] in Australia.

2.2. Information Dissemination during the Process of Recycled Water Promotion

Given the importance of public acceptance for the successful implementation of recycled water use projects in green communities, more and more scholars are trying to understand how to effectively convey information to the public to increase their willingness to accept recycled water during the promotion process [16]. In general, most of the existing studies agree that information strategies have a positive effect on increasing public acceptance of recycled water [50]. Among them, some scholars have carried out field experiments and found that large-scale publicity campaigns can increase the public's willingness to accept recycled water use [51,52]. It has also been found that people who had seen recycled water signage or attended recycled water exhibits are more supportive of recycled water use than those who have not noticed the signage or have never attended a recycled water-related exhibit [53]. In addition, many scholars have taken online methods to provide information for the public about different aspects of recycled water, which has resulted in positive results. The information includes the safety indicators of recycled water [17], the treatment process of recycled water [17], and benefits of recycled water [21], etc. These studies showed that compared to those who did not receive the information, people who received such information had a higher level of knowledge about recycled water, a lower level of perceived risk, a higher level of trust in stakeholders, and a higher willingness to accept recycled water use [18].

2.3. Message Framing in Advertising and Its Impact on Public Decision Making

Advertising messages often use different words, pictures, or phrases to compose different frames to highlight the benefits that may be obtained by purchasing or using the product or to emphasize the costs and penalties caused by not purchasing or using the product in order to influence consumers' attention and memory and achieve the purpose of attracting them to purchase the products [54]. In recent years, more and more scholars have begun to pay attention to the application of message frames in advertising persuasion [55]. Many studies have been conducted through traditional experimental approaches. For example, some scholars have found through field research that the presentation of promotional messages in different frames makes a significant difference in the perceived strength of the promotional strategy and thus affects people's purchase intentions [56]. There is an empirical study using a questionnaire method, and their results showed that compared to negative expressions, describing possible weather conditions in positive language can increase consumer behavior in booking hotels [57]. In addition, scholars have utilized experimental methods of cognitive neuroscience to explore the effects of message frames in various contexts. For example, one study used eye-tracking technology to investigate how message framing affects viewers' attention and cognitive processes in print advertisements for osteoporosis prevention. It found that the fixation count, fixation duration, and recall rates were higher for osteoporosis prevention advertisements described with gain frames than those described with lost frames and neutral frames. Fixation count, fixation duration, and recall rate were positively correlated in both gain frames and neutral frames [58]. Some studies have used Event-related potentials (ERPs) measures to examine the effect of attribute framing on consumer behavior in online shopping information processing and decision making. They found that participants in the positive framing condition exhibited higher purchase intentions and shorter response times, allowing consumers to perceive better product performance [59].

2.4. Study Problem

It is acknowledged that in order to alleviate the water scarcity problem, it is urgent to adopt targeted and effective strategies to increase public acceptance of recycled water use. Information dissemination policies, compared to other alternatives (e.g., monetary incentives, enactment of laws, etc.), have the advantages of lower costs and wider audiences. Therefore, for a long time, relevant government departments or project stakeholders often use information strategies to persuade the public to change their minds or behavior. However, while information strategies are able to reach a large number of the target population, the expected effects after implementation are still highly uncertain and, therefore, often subject to criticism [60].

Consequently, it is necessary to systematically explore the design schemes to improve the effectiveness of advertising information [61]. It is an excellent way to learn from relevant theories of message frames in advertisement design. However, to date, few scholars have tested the persuasive effect of different types of message framing on the public regarding the acceptance of recycled water. Therefore, it is essential to explore the best possible way to construct the information content of recycled water advertising messages and to understand what kind of message framing will positively influence the public's willingness to accept recycled water.

Based on previous studies, this study adopts a specific type of advertising tool, posters, for the publicity and promotion of recycled water treatment and the use of technology in the community [60]. It uses posters as the information carrier. The message frame was embedded into the poster on the one hand, and the reference points were subdivided on the other hand. An experimental method in cognitive neuroscience, eye-tracking, was introduced to obtain eye-movement behavior data that could reflect the thinking process of participants when they read the poster. "Fixation" is one of the most important indicators of individuals' internal cognitive process of external information. Studies have shown that people's fixation on external information is synchronized with the process of thinking about the information in their minds [35,36]. The duration of fixation reflects the amount of time the brain spends cognitively processing information, and the longer an individual fixates on an area, the more attractive the information presented in that area is [36]. This study also combines the keystroke decision data of the experimental participants to uncover the underlying mechanism by which the message frame and reference point jointly influence the public's cognitive behavior towards recycled water advertising and willingness to accept recycled water. It aims to provide a reference for the information and publicity policy of recycled water promotion in green communities.

3. Theoretical Framework and Research Hypotheses

3.1. Message Framing and the Public's Willingness to Accept Recycled Water

Message frame originated from the prospect theory proposed by Kahneman and Tversky [62], which refers to conveying information with the same meaning through different forms and wordings of linguistic expressions, so that information recipients have different cognitions and judgments of the information expressions, thereby enhancing the persuasive power of language and achieving effective information transfer [19]. Subsequently, Levin et al. further classified framing effects into three categories, including risk framing, attribute framing, and goal framing [20]. In the field of consumer psychology and behavior research, goal framing is the most used communication strategy. Under the goal framing, information about decision options is described in terms of the potential gains from accepting the behavior (gain frame) or the potential losses from not accepting the behavior (loss frame) [63]. The public, as recipients of recycled water advertisements, usually have different levels of motivation to process information when faced with two types of information: gain-framed message and loss-framed message and may differ in their level of attention to the two types of information [64]. The persuasive effect of advertising depends on the degree to which the public processes the message. The Elaboration Likelihood Model (ELM), one of the most influential theoretical models in the study of consumer information processing, suggests

that there are two basic modes of this process by which individuals process information, one that is conscious, analytical, based on logic and invested with effort (Central Route), and the other that is automatic, heuristic, based on emotion and without effort (Peripheral Route) [65]. Previous studies have typically measured individuals' cognitive effort using the Cognitive Engagement Scale [66]. Since subjects often actively avoid certain questions when answering, or the measurement is inaccurate or even fails due to the halo effect [5], a more accurate measure is needed to directly measure the degree of information processing and cognitive effort of subjects.

Information processing is mainly dependent on vision, and about 80% to 90% of external information is obtained through fixation [67]. The Eye-Mind Hypothesis holds that the process of people's fixation on external information is synchronized with the process of thinking about information in mind. When an individual's brain processes a specific area of text, their eyes will focus on that area [68]. Eye-tracking equipment can capture users' eye-movement behavior and record it in objective data [69]. In this study, the average duration of fixations was chosen to measure public attention to recycled water poster information. The average duration of fixations is an essential indicator of the user's attention to the Area of Interest (AOI), one of the important metrics that reflect how much attention users pay to the AOI [70]. It can reflect the brain's processing time of information. The longer the average duration of fixations, the more cognitive effort users put into that area [68].

Based on previous research, Rothman and Salovey also further confirmed that when convincing the public to adopt "preventive" behaviors, the use of the gain frame is more effective than the loss frame [71]. The promotion of recycled water is precisely to "prevent" the occurrence of shortage or pollution of the earth's water resources, which affects the normal life of the public or poses a threat to human health. Accordingly, this study argues that messages that emphasize the benefits of using recycled water (the gain-framed message) will be more attractive than messages that emphasize the costs of not using recycled water (the loss-framed message), according to the prevention-detection framework. Hypothesis 1 is proposed:

Hypothesis 1. *Message framing influences public perception of recycled water use advertising messages: the average duration of public fixations on gain-framed messages is longer than that of the loss-framed messages.*

3.2. Reference Point: Self-Referencing versus Other-Referencing

The reference point is an important concept introduced along with prospect theory. In his analysis of people's decision-making biases in real life, Kahneman pointed out that people's decision-making behavior has a reference-dependent effect [62]. An individual's cognitive system processes and stores information described to the self and information related to others in different ways [72]. Scholars generally agree that self-referencing is more convincing than other-referencing [73]. When people see information relevant to their interests, they increase individual engagement and activate more cognitive resources to process the information [74,75]. In addition, the in-depth processing of information by audiences leads to more profound memories and persuasive effects that influence their attitudes and behavioural decisions.

Similarly, according to ELM, since the self-referencing message emphasizes the health, safety, and efficiency of recycled water, and these appeal points are closely related to the public's own interests. The public will be more willing to think systematically about information that is highly relevant to them and will go through the central route for systematic mental processing. They will carefully evaluate the beneficial attributes of recycled water and will be more likely to accept recycled water, thus producing a positive effect. The other-referencing message emphasizes the environmental benefits of using recycled water for others, communities, or cities, such as environmental protection and low carbon. It has less relevance to the message recipients' own interests. At this time, they will

process the message through the peripheral route. Therefore, this study concludes that the influence of self-referencing messages is more powerful than that of other-referencing in the process of promoting recycled water use projects. Hypothesis 2 is proposed:

Hypothesis 2. *Reference points affect the public's cognitive behavior towards recycled water advertising messages: the average duration of fixations on self-referencing messages is longer than it is referencing by others.*

3.3. The Moderating Effect of Reference Point on Message Frame

The matching effect resulting from the combination of factors affecting individual message elaboration enhances the audience's cognitive processing of the message, which in turn leads to positive attitudes and behaviors [76]. For example, regulatory fit theory suggests that when information frames match an individual's regulatory focus (i.e., the way an individual thinks about goals), they are motivated to elaborate on the message and support the ideas in the message [77]. In addition, studies have shown a significant interaction between message frame and reference point. When the message is loss-framed, the other-referencing message will make the public more willing to get the influenza vaccine than the self-referencing message. When the message is gain-framed, the self-referencing message is more effective than the other-referencing message [78]. It has also been found that when a message was expressed using a negative frame, the experimental participants who had read self-referencing messages had lower levels of comprehension and lower recall rates compared to those other-referencing [79].

For recycled water use posters, the matching between the message frame and the reference point is also likely to promote the public's cognitive processing of the information. Self-referencing messages combined with the messages frame can lead people to imagine scenarios where positive (negative) outcomes of using (not using) recycled water. In contrast, an other-referencing message combined with the message frame can allow people to think about scenarios where negative or positive outcomes occur to others [75]. The hedonic principle posits that individuals tend to seek pleasure and avoid pain [76]. The Inconsistency-Negativity neglect model suggests that individuals have a motivation to ignore negative information in order to protect themselves from it [78]. Therefore, based on the above theory, this study argues that self-referencing messages motivate people to elaborate on the message more than other-referencing messages when the recycled water poster message is gain-framed because gain framing can lead the public to consider the potential benefits or advantages of using recycled water. When a recycled water poster message uses a loss frame, the other-referencing message will allow the public to elaborate on the message in more detail because individuals want to avoid suffering losses or disadvantages. Hypothesis 3 is proposed:

Hypothesis 3. *Message framing interacts with reference points on the public's cognitive behavior of recycled water advertising: for self-referencing information, the gain frame has a longer average duration of fixations than the loss frame, and for other-referencing information, the loss frame is longer than the gain frame.*

3.4. The Mediation Effect of Eye-Movement Behavior

The psychological process of the influence of message framing on individual behavior has been a hot research topic in the academic community. The effect of message framing on behavioral intentions can be moderated by factors such as the individual's elaboration of the message [79], the fluency of message processing [80], and the attitude held toward the behavior [81]. It has been found that cognitive elaboration mediates the effect of framing effects on behavior change [79,82]. ELM also states that when individuals use many cognitive resources to read messages carefully, they use the central route to elaborate and thus change behavior more effectively than those who use peripheral cues to process

messages [65]. The deeper the individual's elaboration of the information, the stronger the individual's behavioral intentions will be. Therefore, when individuals are strongly motivated and sufficiently empowered to think about recycled water advertising messages through multiple cues and evidence and generate a stronger cognitive effort to read them, the resulting strong attitudes are likely to lead the public to support recycled water use. Otherwise, the public will only process the information at a superficial level, resulting in little success in the advertising and promotion of recycled water. Therefore, this study argues that the combined effect of message framing and reference points in recycled water posters on the public's willingness to accept recycled water could be achieved by influencing the public's message cognition and message elaboration. Hypothesis 4 is proposed:

Hypothesis 4. *The interaction effect between message frame and reference point influences the public's willingness to accept recycled water through elaborative processing of the message.*

In summary, the research framework of this paper is shown in Figure 1.

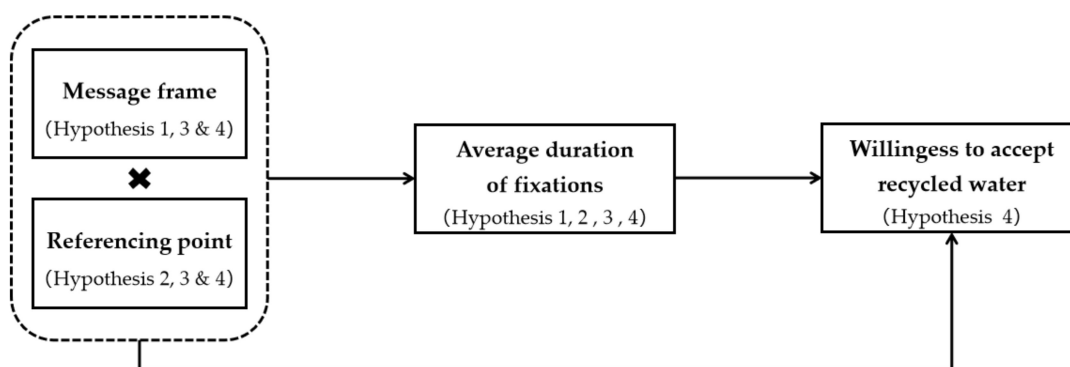


Figure 1. Research framework.

4. Methods

4.1. Experimental Participants

An experiment participant accepts information from different frameworks or different reference points, which is likely to cause a learning effect, and in turn, result in inaccurate results. Therefore, this experiment adopts a completely between-group experiment, with one participant only receiving one message frame in combination with one reference point to generate the recycled water advertisement. This experiment employed a 2 (message frame: gain vs. loss) \times 2 (reference point: self vs. other) between-subjects factorial design. The eye-tracking experiment was conducted at Xi'an University of Architecture and Technology from 15 January to 23 January 2022. A total of 61 participants with normal vision were recruited, all of whom were between the age of 21 and 25, with a male to female ratio close to 1:1.

Prior to the commencement of experiments, the participants were relayed the information about recycled water that, "In this study, recycled water is a generic term for water reclamation and reuse. It refers to highly treated wastewater that has been filtered to remove solids and other impurities as well as disinfected by a water treatment plant. It comes from various sources such as domestic sewage, industrial wastewater, and stormwater runoff. The quality of recycled water depends upon the source water and the level of treatment. This study does not include the option of using it for portable purposes." After that, participants were randomly assigned to each experimental group and were asked to read the poster messages carefully and make keystroke decisions in turn during the experiment. Upon completion of the experiment, each experiment participant received RMB 20 (Equivalent USD 3) as a 'thank you' gesture. We obtained valid eye-movement data from 60 experimental participants after eliminating one experimental sample with too many blinks resulting in low sampling rates. According to the reviews of eye-tracking

studies by Alemdag [83] and Ashraf [84], the majority (84.71%) of existing eye-tracking experiments had a participant size between 8 and 60. Hence, the sample size requirement for eye-tracking experiments was met in this study.

4.2. Experimental Equipment

This experiment used the Tobii Pro Fusion eye-tracking device to collect eye-movement data from the participants in the experiment. We set the computer screen display resolution to 1920×1080 , and the screen scaling ratio to 100%. Then we connected the eye-tracking device to the laptop through the Type-C port to present the stimulus material (i.e., the recycled water promotional poster) on the screen. In addition, we controlled the distance between the screen and the eyes of the experimental participant to be about 60 cm during the experiment. We used the Tobii Pro Lab software supporting the eye tracker to complete the tasks of each stage in the eye-tracking experiment, including stimulus programming, keystroke response recording, eye movement data acquisition, and visualization.

4.3. Stimulus Material

This study used Photoshop to design the posters for the promotion of recycled water. Figure 2 shows one of the sixteen sets of recycled water posters. In addition to the text area (AOI) created by combining the message frame and reference point, the poster also includes the headline “Please use recycled water” and a scene diagram of the use of recycled water to increase the sense of contextual substitution. The four posters in each of the four groups have the same composition, the same background image, and almost the same number of texts. They differ in that they contain four types of information generated by the combination of message frame and reference point. For example, “you would probably receive compliments if you use recycled water.” (referring to the text in the ‘Self’ section in Figure 2). Another example is that, “your community would probably receive compliments if you use recycled water” (referring to the text in the ‘Others’ section in Figure 2). The four control-group posters were kept to show almost the same number of texts and avoided highly positive or extremely negative messages while ensuring that the content was unambiguous.



Figure 2. Cont.



Figure 2. Examples of stimulus materials. (Note: The text in the posters that we showed to our participants was in Chinese. The text in Figure 2 is a direct translation of the Chinese text into English.)

4.4. Experimental Procedures

On the premise that recycled water is safe, the primary motivation for the public to accept it is the urgent need for water. Participants were asked to imagine they were in this situation before the experiment. The experimental procedure is shown in Figure 3. First, eye movement calibration was performed on the experimental participants. After completing the calibration procedure, the experimental program entered the formal experiment interface on the basis of ensuring that the experiment participants had read the instructions and understood the essential operation of the experiment. The first screen showed a cross-shaped logo with a duration of 800 ms to focus the eyes and attention of the experiment participants. It is followed by a recycled water poster, which the experiment participants have 12 s to browse freely. Next, a blank screen appeared for 800 ms. After the blank screen, a decision-making interface appeared, which was used to guide the experiment participants to make keystroke responses about their willingness to accept recycled water. Willingness to accept was measured on a seven-point Likert scale (button “1” for very reluctant and button “7” for very willing). The above was the experimental procedure for a single promotional poster. The cycle was repeated until each of the 16 posters was presented once in random order. After the eye-tracking experiment was completed, the experiment participants were invited to fill in some simple sociodemographic questions. The entire experiment lasted about 15 min.

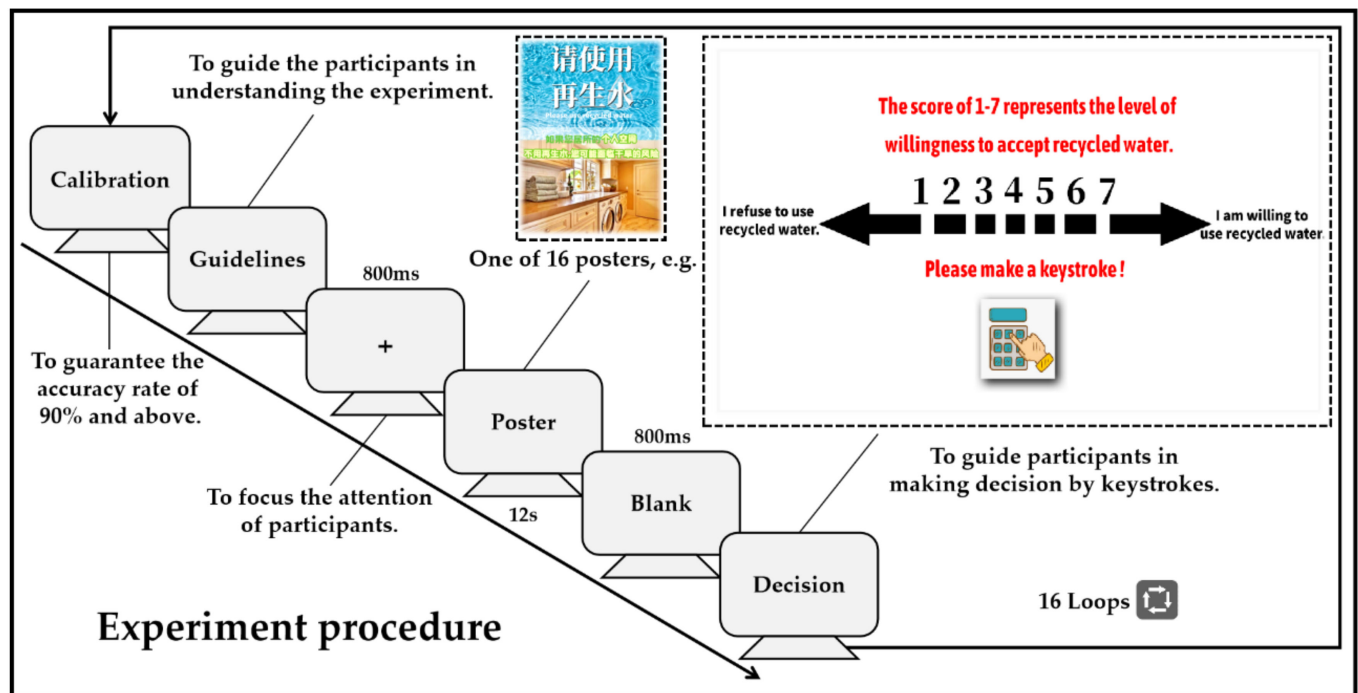


Figure 3. Stimulation Procedure of Eye-tracking, the screen and keyboard, and the options presented to the participants.

5. Results

5.1. Influence of Message Frame and Reference Point on Eye-Movement Behavior

The duration of the participants' fixations on the AOI can be reflected visually by the heat map, in which different colors represent the different duration of the participants' fixation on the area. The darker the color is, the longer the duration of the fixation lasts. The red area represents the longest fixation time, followed by the yellow area, and the green area represents the shortest fixation time. The uncolored area means that the experimental participants did not look at the area. Figure 4a,b show the heat maps obtained by overlaying and visualizing the eye-movement data of the gain-framed message group and the loss-framed message group, respectively. Comparing the color and color depth of the AOI in the heat map, we found that the total fixation time of the experimental participants on the promotion information of the recycled water poster using the gain-framed message is longer compared to using the loss-framed message. In order to more accurately compare the differences in the degree of participants' attention to the two types of framed messages, we used IBM SPSS Statistics 26 to conduct independent samples *t*-test on the average duration of fixations of the participants under both framed conditions. The results showed a statistically significant difference in the average duration of fixations between the two conditions ($t = 2.404, p < 0.05$). The average duration of fixations for the gain-framed message group was 238.760 ± 54.320 ms, and the average duration of fixations for the loss-framed group was 229.480 ± 64.830 ms.

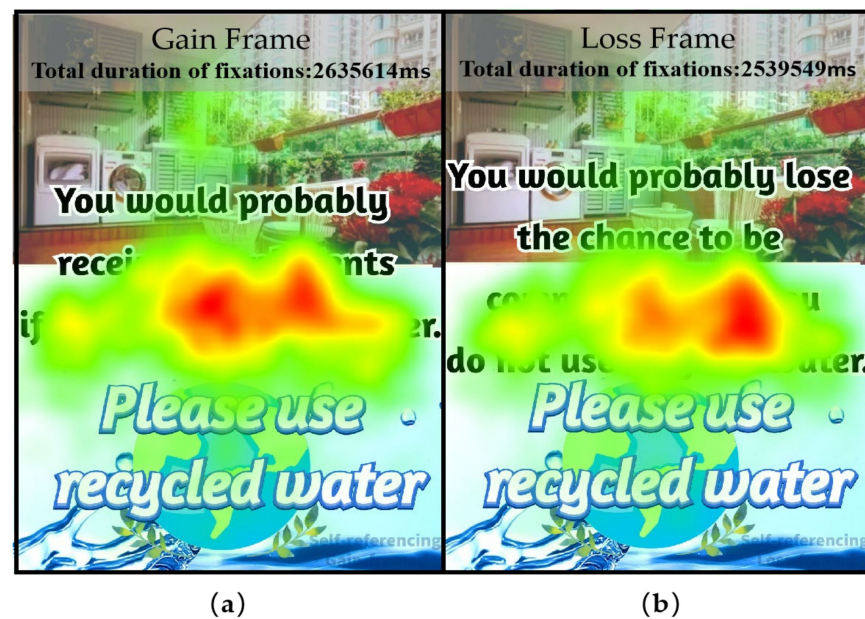


Figure 4. Eye-tracking heat map of posters with different message frames. (a) Eye-tracking heat map of gain frame; (b) Eye-tracking heat map of loss frame.

Similarly, Figure 5a,b respectively show the heatmaps obtained by superimposing and visualizing the eye movement data under the self-referencing condition and the other-referencing condition. We compared the color and color depth in the heat map and found that the total fixation time of participants on the poster message was longer under the self-referencing condition. An independent sample *t*-test of the average duration of fixations of the participants under the two conditions showed that the difference between the average duration of fixations under the two conditions was statistically significant ($t = 2.385, p < 0.05$). The average duration of fixations was 238.730 ± 57.800 ms for the self-referencing group and 229.520 ± 61.760 ms for the other-referencing group.

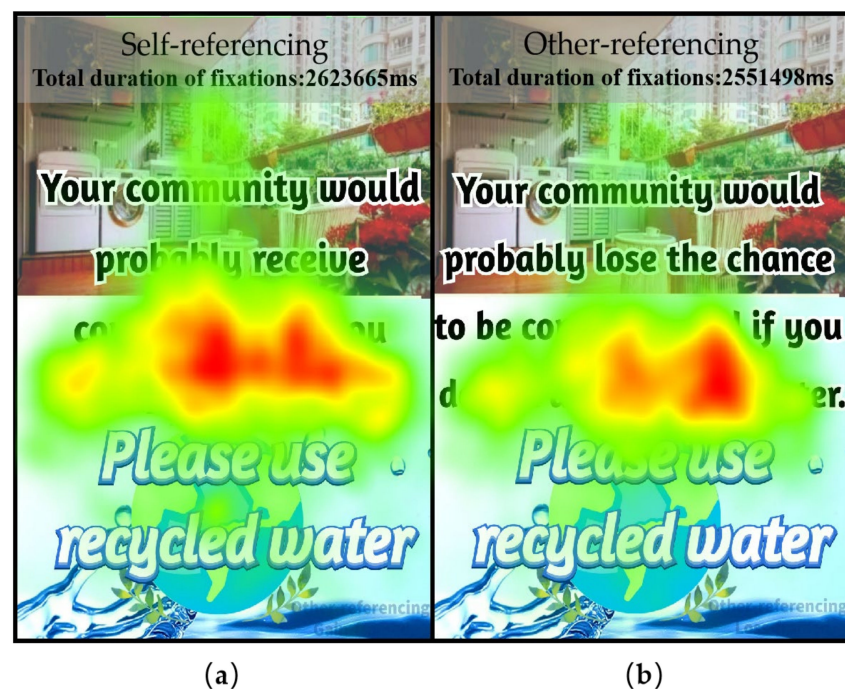


Figure 5. Eye-tracking heat map of posters with different points of reference. (a) Eye-tracking heat map of self-referencing; (b) Eye-tracking heat map of other-referencing.

5.2. Interaction Effect of Message Frame and Reference Point on Average Duration of Fixations

In this study, message frame and reference point are independent variables, and both are categorical variables. The average duration of fixations is a continuous dependent variable. Therefore, two-way ANOVA was used to test the interaction effects of message frame and reference point on the average duration of fixations. The results showed a significant effect of the interaction between information frame and reference point on the average duration of fixations ($F(1, 956) = 11.837, p = 0.001$). As shown in Figure 6, the average duration of fixations for the gain-framed message was significantly longer than that for the loss-framed message under self-referencing condition. In contrast, the average duration of fixations for loss-framed messages was significantly longer for participants than that for gain-framed messages under other-referencing conditions.

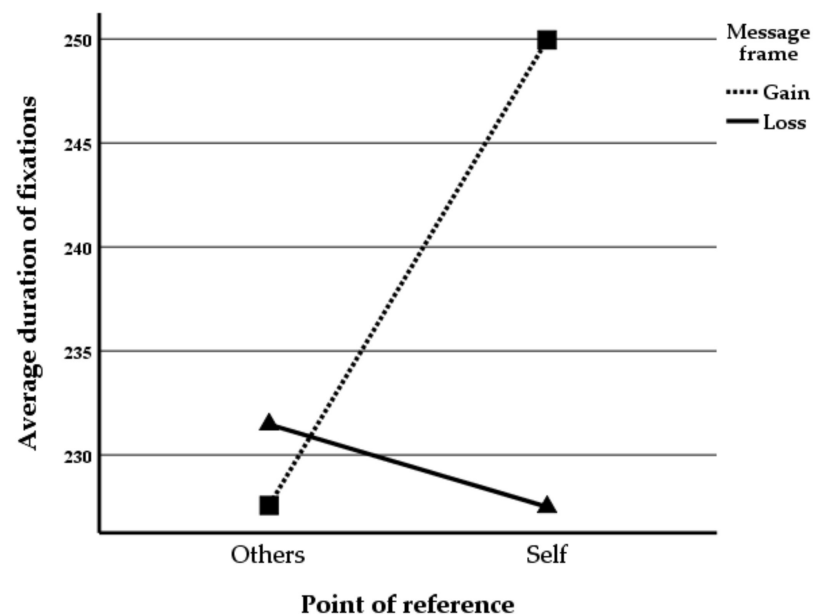


Figure 6. Interaction effect of message frame and reference point on the average duration of fixations.

5.3. The Mediating Role of Average Duration of Fixations

Based on SPSS, Andrew F. Hayes developed “PROCESS”, a plug-in for mediated effects analysis [85]. The PROCESS macro is essentially a modification to statistical programs like SPSS that computes regression analyzes containing various combinations of mediators, moderators, and covariates. It is widely used for estimating direct and indirect effects in mediator models, two- and three-way interactions in moderation models, along with simple slopes and regions of significance for probing interactions [85]. PROCESS makes it possible to analyze mediating effects in one step, which simplifies the process considerably. Furthermore, PROCESS makes it easier to handle multivariate mediating and moderating effects.

The mediation effect of eye-movement behavior was tested by selecting Model 4 for 5000 draws at 95% confidence intervals using the PROCESS method. The results (shown in Figure 7) showed the mediating effect of the average duration of fixations was significant (Index = 0.028, SE = 0.012, 95% CI = [0.008–0.055]). Further detailed analysis of the mediating effect can be found in Tables A1 and A2.

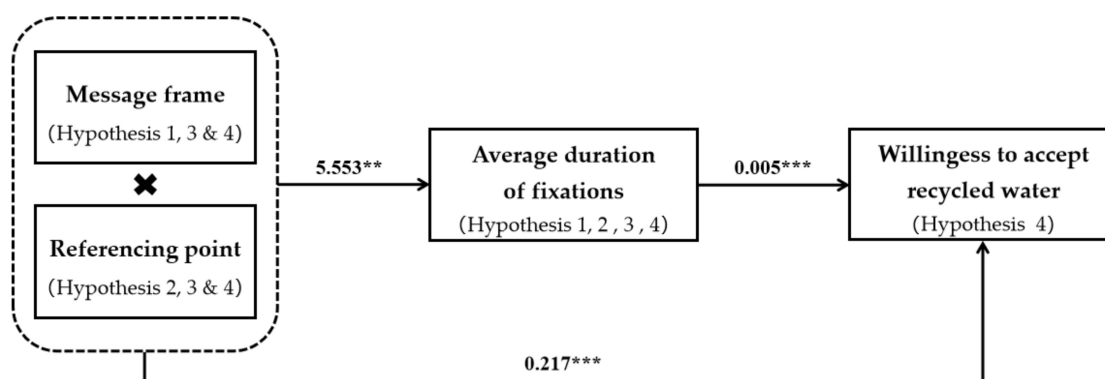


Figure 7. Mediating effect of Average duration of fixations. (Note: The values in the Figure 7 are standardized regression coefficients; ** $p < 0.01$, *** $p < 0.001$).

6. Discussion

This study explored the influence of message frame, reference point, and their interaction in the publicity posters of recycled water on the public's willingness to accept recycled water. It also analyzed the mediating effect of the people's eye-movement behavior when reading the posters. Below are the main findings.

(1) A gain-framed promotional message produces better results than a loss-framed message. By observing the heat maps formed after visualizing the eye-tracking experimental data and using the independent sample t -test to compare the average duration of fixation points of the participants under different frameworks, it is found that compared to the loss-framed messages, the public had a longer average duration of fixations on the gain-framed messages. This reflects the public's more significant cognitive effort into this advocacy strategy. Hypothesis 1 is accepted.

Without taking other factors into account, different framed messages about recycled water will lead to different psychological perceptions and psychological states of the public, and the resulting cognitive behavior of the public will also vary. This confirms the hedonic principle and inconsistency-negativity neglect model [77,78]. Gain-framed messages lead to positive associations and positive emotions for the public, and loss-framed messages lead to negative associations and negative emotions for the public. Since the pain of loss can be far greater than the pleasure of gain, the public is more likely to focus on the gain-framed messages and avoid reading the loss-framed ones [22]. The findings enrich scholars' understanding of prospect theory, expand the application scenarios of the message frame, and explain the controversy over the gain frame and loss frame in the existing literature. Furthermore, the findings enlighten scholars that to predict individual behavior more accurately, the study should be contextualized when studying the influence of message frames on public decision-making.

(2) Self-referencing message is more suitable for recycled water promotion than the other-referencing message. By observing the heatmaps and comparing the average duration of fixations of participants at different reference points using independent samples t -test, it is found that the average duration of fixations on self-referencing information was longer than on other-referencing information. This suggests that the public would make more effort in cognitive processing of self-referencing information. Hypothesis 2 is accepted. Therefore, without taking other factors into account, the use of the self-referencing message is likely to be more effective than the use of an other-referencing message in the advocacy strategy on recycled water. The findings confirm the validity of the strategy of segmenting advertising messages by self or other reference points. In addition, the findings are highly generalizable and address future research opportunities for scholars to explore the impact of reference points in other contexts.

(3) Message frame and reference point have an interactive effect on the public's message elaboration behaviour. The results of the two-way ANOVA indicated that people

had a longer average duration of fixations on gain-framed messages under self-referencing conditions compared to loss-framed messages. On the other hand, people had a longer average duration of fixations on loss-framed messages under other-referencing conditions, compared to gain-framed messages. This illustrates that under self-referencing conditions, the public pays more attention to the advertising messages expressed using the gain frame. While under the other-referencing condition, the public pays more attention to the advertising messages expressed using the loss frame. Hypothesis 3 is accepted. This suggests that people are more inclined to seek information that is beneficial to them than unpleasant information [77,86]. The study expands the research field of information strategy by combining message frames with reference points in exploring differences in the impact of different combinations of message frames and reference points on public willingness and behavior regarding recycled water use. We suggest that when studying the persuasiveness of advertisements containing two or more elements, scholars should consider the effect of matching or correlation between elements on the persuasiveness of the advertisements.

(4) The average duration of fixations on the advertising message mediates the path in which the message frame and the reference point jointly influence public acceptance. This finding was tested using the Process method. The matching of message frames and reference points in recycled water use posters can influence the public's willingness to accept recycled water not only directly but also indirectly through the public's eye-movement behavior. This finding validates that the framing effect can have an impact on individuals' behavioral intentions through message elaboration and cognitive effort [79,82,87,88]. Hypothesis 4 is accepted. The results validated the use of eye-tracking technology in studying the effects of recycled water advertising strategy by exploring the underlying mechanism of the impact of recycled water advertising strategies on community acceptance of recycled water using an eye-tracking experiment.

7. Conclusions

In conclusion, this paper provides practical guidance and theoretical support for the effective use of information strategies to change negative public stereotypes of recycled water, which in turn would increase public acceptance of recycled water and promote the use of recycled water in green communities. The findings of this paper show that the public responds more strongly to the use of the gain-framed messages than to the use of loss-framed messages in recycled water promotional posters. They also react more strongly to the use of self-referencing messages than to the use of other-referencing messages in the same context. When the message frame and reference point are matched with each other, stressing the benefits of using recycled water for oneself or the losses of not using recycled water for others will have a more persuasive effect on the public than emphasizing the benefits of using recycled water to others or the losses of not using recycled water to oneself.

8. Limitation and Future Research Opportunities

Although this study was based on a rigorous theoretical foundation and employed standard experimental methods, inevitably, there are some limitations due to the experimental conditions and the impact of the epidemic. (1) As the experiment was conducted during the epidemic when the city had adopted COVID restrictions, it was difficult to recruit experimental participants in the community. Consequently, the participants of this eye movement experiment were all students from the Xi'an University of Architecture and Technology, Xi'an, China. Although the data obtained in this way have high internal validity, whether it can be extended to other age groups and educational levels needs to be further tested. (2) In addition, it is argued that when experimental participants are in the laboratory, their pro-social behavior and willingness are not only influenced by advertising messages but may also be disturbed by the environment [89]. In future research, more cognitive neuroscience methods, such as electroencephalography [90] and functional magnetic

resonance imaging [91], could be used to advance the understanding of public acceptance of recycled water in different scenarios.

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Institutional Review Board Statement: The experiment strictly complied with the Declaration of Helsinki. The Internal Review Board of the Laboratory of Neuromanagement in Engineering approved this study.

Informed Consent Statement: Written informed consent has been obtained from the experiment participants to publish this paper.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Decomposition table for total, direct, and mediated effects.

	Effect	BootSE	BootLLCI	BootULCI	Relative Effect
Total effect	0.245	0.037	0.171	0.318	
Mediated effect	0.028	0.012	0.008	0.055	11.57%
Direct effect	0.217	0.037	0.143	0.289	88.43%

Table A2. Results of the mediating effect test.

	WTA		WTA		ADF	
	<i>t</i>	<i>p</i>	<i>t</i>	<i>p</i>	<i>t</i>	<i>p</i>
ADF	7.368	0.000				
MF*RF	5.828	0.000	6.450	0.00	3.224	0.001
R		0.305		0.204		0.014
R²		0.093		0.042		0.011
F		49.103		41.600		10.396

Note: ADF means the average duration of fixations; WTP means the willingness to accept recycled water. MF*RF means message frame*referencing point.

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