Can the Visualization of Rip Currents Prevent Drowning Accidents? Consideration of the Effect of Optimism Bias

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Abstract

Almost all drowning accidents in Japan are caused by rip currents. To reduce these accidents, a new technology that can detect rip currents and notify beachgoers by using the Internet of Things (IoT) and Artificial Intelligence (AI) was proposed. However, studies on the effect of visualizing rip currents or considering the effect of optimism bias have not been conducted. This study investigates if visualization of rip currents might help in preventing drowning accidents, while considering the effect of optimism bias. The participants were 90 Japanese beachgoers. They were asked to answer questions based on their knowledge of the beach and rip currents, their optimism bias regarding rip currents, and awareness with or without visualization. The results of the analyses suggest that despite optimism bias, the visualization of rip currents increases the tendency of beachgoers to perceive and avoid rip currents. As described above, it found that by visualizing rip currents, beachgoers can avoid. Additionally, an understanding of rip currents is positively related to the intent to avoid rip currents with visualization. Therefore, it is necessary not only to enhance the avoidance tendency by visualizing rip currents, but also to further enhance knowledge of beachgoers to deepen the understanding of rip currents including the danger associated and methods to avoid them.

Introduction

Ⅰ. Drowning accidents caused across the world by rip currents

Japan has approximately 35,000 km of ocean coastline. More than 20 million people visit the 1,250 beaches across the nation and enjoy swimming in the summer season. However, every year, many drowning accidents occur, and precious lives are lost. About 1,300 to 1,600 drowning accidents occur in Japan each year, and about 1,500 to 2,000 people drown (National Police Agency, 2020). Rip currents are responsible for 45% of these drowning accidents (Ishikawa et al., 2014). Rip currents (often called “rips” or “rip tides”) are strong, narrow seaward flows arising from alongshore variations in wave setup landward of the breaker zone. Due to their dependence on wave breaking, rips can develop in any beach environment in oceanic, sea, and lacustrine environments (Houser et al., 2017). There are many drowning accidents caused by rip currents in foreign countries. More than 50% of drowning accidents reported in Australia, the United States, and the United Kingdom, were caused by rip currents (Brighton et al., 2013). Therefore, it is necessary to prevent these accidents on a global scale.

Ⅱ. Efforts to prevent drowning accidents caused by rip currents

Morgan, Ozanne-Smith, and Triggs (2009) found that gender, age, alcohol consumption, overconfidence in swimming ability, and lack of knowledge about rip currents, are associated with drowning accidents by rip currents. Caldwell et al. (2013) and Brannstrom et al. (2014), showed beachgoers pictures of rips and asking them to identify the area of the currents, reported that most of them misidentified the area. Warning signs are put up at many beaches to inform people of rip currents (Ménard et al., 2018). In addition to warning signs, in many jurisdictions flags are used to indicate lifesaving surveillance areas,

safe swimming areas, or rip currents and other hazards. However, previous studies evaluating the effectiveness of warning signs, indicated that less than half the beachgoers were not aware of signs posted on the beach (Matthews, Andronaco, & Adams, 2014; Brannstrom et al., 2015; Kaminski et al., 2017). It has also been reported that many people did not prepare for or avoid rip currents, even if they were aware of the warning signs (Siegrist & Gutscher, 2006; Karanci, Aksit, and Dirik, 2005; Hall & Slothower, 2009). Furthermore, there are several problems associated with the usage of beach flags. As the color of the flag and its intended meaning differs from country to country, beachgoers from other countries may not be sure of the intended meaning (Ménard et al., 2018). Though lifesavers need to understand topographical features before finding rip currents, it is difficult to indicate the exact area through beach flags (Shimada, Ishikawa, & Komine, 2019). Furthermore, not all beaches are managed by lifesavers or beach flags, and beach flags cannot be set up outside the managed areas. Consequently, there is a possibility that beachgoers may believe that an area is safe and get caught in rip currents that are in areas that are not being managed.

Hatfield et al. (2012) and Houser et al. (2017) suggest that when beachgoers are given sufficient visual information about where rip currents occur, they can identify the area and are more likely to avoid these areas based on their observations. In Australia, lifesavers check the area for rip currents and other dangers, and inform beachgoers by sharing information through a smartphone app (MashableAsia, 2017). However, as the information is fed in at a predetermined time, it is not possible to track the constantly changing situation. In Japan, a new system using IoT has been developed that automatically detects the occurrence of rip currents through AI, and the information is displayed on a digital signage installed at the beach to alert beachgoers (Ishikawa et al., 2019). The advantage of this approach is the ability to display real-time alerts of geographically and temporally changing rip currents regardless of the area and time of the day. Endo et al. (2019) examined the awareness of beachgoers with the use of this approach. Based on a survey of 142 beachgoers, it was reported that more than 90% of them identified rip currents and tried to avoid the area.

Based on the above, it can be deduced that beachgoers can perceive the danger and avoid rip currents by visualizing them.

Ⅷ. The effect of cognitive bias

As reported in a previous study (Endo et al., 2019), visualization of rip currents through AI is an effective method to prevent drowning accidents. However, the study did not consider the effect of beachgoer's cognition of rip currents. Ménard et al. (2018) pointed out that beachgoers are affected by cognitive bias to avoid rip currents. Confirmation bias is the most common bias, which is the cognitive tendency to focus on evidence that supports one's beliefs or decisions and to ignore evidence that disproves them. This bias can make people look for evidence that it is safe to swim (for example, there are other people in the sea, there are no waves) and ignore evidence that it is not safe to swim (for example, there are red flags and warning signs). Scaman (2017) asked participants to evaluate their decision to swim in the sea by showing them photos of beaches with different waves and different number of people. She reported

that although there were rip currents, participants were more likely to enter the sea after seeing photos where people were in the sea than when they saw photos of the same beach without people. The results indicated the impact of confirmation bias, as people make decisions based on the presence and behavior of others, and not on wave conditions. Additionally, if the perception of fear is inadequate, people assume that “It won’t happen to me” and therefore they are safe and can take the risk (Slovic et al., 1981, 1987). This tendency to interpret and predict things according to their advantage and to estimate that their risk is lower than that of others is called optimism bias (Armor & Taylor, 2002; Klein & Weinstein, 1997). Optimism bias has been studied in health problems (for example, the possibility of contracting lifestyle-related diseases or infections). Most people are not afraid of drowning as swimming is considered to be a low fear activity with known risks (Slovic et al., 1981, 1987; Sandman, 1989). Therefore, even if the danger of drowning by rip currents is mentioned, the danger is likely to be underestimated due to optimism bias.

Ⅷ. Purpose of the study

Various efforts have been made to prevent drowning accidents due to rip currents. However, there has been no research on the effect of visualizing rip currents or the impact of optimism bias. Ménard et al. (2018) elaborated on the need for psychological studies to develop strategies to ensure that beachgoers avoid rip currents and prevent drowning accidents. This study investigates if the visualization of rip currents might assist in preventing drowning accidents, while taking into consideration the impact of optimism bias.

Methods

Ⅷ. Place (Figure 1)

This study was conducted at Aoshima beach in Miyazaki Prefecture, Japan, which has rip currents due to the proximity to the sea (Nishi et al., 2005).

Ⅷ. Participants

The survey was conducted with one hundred Japanese beachgoers (43 men, 55 women, and 2 unknown) at Aoshima beach. After excluding those who did not complete the questionnaires, data from a total of 90 participants (41 men, 49 women; $M_{\text{age}} = 36.1$ years, $SD_{\text{age}} = 16.9$ years) were analyzed. The survey was conducted on August 10 and 11, 2019. Before conducting the survey, the purpose and contents of the questionnaire were explained to the head of the beach and permission was taken. Additionally, at the time of the survey, participants were informed that their responses were voluntary and there was no disadvantage of non-participation. Their consent was taken before they responded to the questionnaire.

Ⅷ. Measurements

Participants were asked to answer question associated with the following three survey items. Additionally, the possibility of damage by rip currents, the evaluation of a system for visualizing rip currents, and the intent to return to beaches after visualizing rip currents. However, the details have been omitted as they were not relevant for the purpose of this study.

Ⅷ. Knowledge of the beach and rip currents

The following sections were prepared based on a previous study (Houser et al., 2017): frequency of going to the beach [infrequent (fewer than ten times in my life), once every year typically on vacation, multiple times every year, several times every year, frequently (weekly or daily)], experience of a drowning accident (no experience, experienced), prior information gathering (no, yes), swimming ability (unable to swim, weak swimmer, competent swimmer, highly competent swimmer), and understanding of rip currents (do not understand, understand, understand well). The participants who stated “understand” or “understand well” were asked to describe rip currents in detail. After the participants responded to these questions, to unify their understanding, rip currents were explained in detail through this image (Figure 2).

Ⅷ. Optimism bias about rip currents

Studies have not measured optimism bias regarding rip currents. Based on previous studies and approaches that have been used to measure optimism bias (Oikawa & Oikawa, 2010; Sasatake, 2014; Shepperd et al., 2013), the participants were asked to judge the possibility of them being caught in rip currents and the possibility of others being caught in rip currents. They were asked to rate the chances for themselves and others from 0% (never get caught in) to 100% (definitely get caught in).

Ⅷ. Awareness of beachgoers with or without visualization

Based on previous studies (Endo et al., 2019), we prepared three sections: the recognition of the area of rip current, the degree of danger, and the intent to avoid rip currents. Participants were asked to rate their awareness from 0% (cannot understand at all, not at all dangerous, cannot avoid) to 100% (can understand, extremely dangerous, can avoid). In terms of visualization, the participants were asked to respond to the questions after seeing the image of rip currents (Figure 3).

Ⅷ. Statistical analyses

First, descriptive analysis was conducted to summarize the knowledge of the participants about going to the beach and rip currents. Second, we examined if optimism bias was observed in participants. Those who rated that the possibility of them getting caught in rip currents is less than 50%, or their possibility of getting caught is less than 50%, but rated that the possibility of others getting caught is higher than theirs, were judged to have an optimism bias. Third, paired t-tests were carried out for the difference between the awareness without visualization and the awareness with visualization for people with optimism bias. Fourth, Pearson’s product moment correlation coefficients were calculated to examine the relationship between each variable. For the analysis, the following variables were dummy coded: gender (0: female, 1: male), frequency of going to the beach (0: infrequent and once every year typically on

vacation, 1: multiple times every year, several times every year, frequent), experience of a drowning accident (0: no experience, 1: experienced), prior information gathering (0: no, 1: yes), swimming ability (0: unable to swim and weak swimmer, 1: competent swimmer and highly competent swimmer), and understanding of rip currents (0: do not understand, 1: understand and understand well). Finally, a hierarchical multiple regression analysis was performed with the intent to avoid rip currents as a dependent variable. While analyzing, based on Cohen (1992), we eliminated the relationships with a low correlation coefficient ($r < .20$). Demographic data were entered in the first step as control variables. The scores of awareness of beachgoers without visualization were entered in the second step. Finally, the scores of awareness of beachgoers after visualization were entered in the third step. Statistical analyses were performed using SPSS (Version 25.0) with the level of significance set at 5%.

Results

Ⅹ. Sample characteristics

The results of the sample characteristics are presented in Table 1. “Once every year typically on vacation” was mentioned as the frequency of going to the beach by 37 participants, which is the highest (41.1%). “No experience” for experience of a drowning accident was mentioned by 85 participants (94.4%), which implied that most participants did not have any experience of drowning accidents. “No” for prior information gathering was mentioned by 46 (51.1%) participants, which implied that approximately half of the participants gathered information about the beach. “Competent swimmer” and “highly competent swimmer” for swimming ability was stated by 35 (38.9%) and 27 (30.0%) participants respectively, which indicated that more than half of them could swim. “Not understand” for understanding of rip currents was stated by 53 participants (58.9%), which implied that more than half of them did not understand the phenomenon.

Ⅹ. Optimism bias for rip currents

Based on the set criteria, we examined if the participants are affected by optimism bias about rip currents. It was observed that 63 of 93 participants (33 men and 30 women) experienced optimism bias. These participants rated the possibility of others getting caught in rip currents ($M_{\%} = 48.89\%$, $SD_{\%} = 23.08\%$) as significantly higher than their own ($M_{\%} = 32.86\%$, $SD_{\%} = 19.00\%$) [$t(62) = -4.54$, $p < .001$, $d = 0.76$].

Ⅹ. Awareness of beachgoers with or without visualization

Paired t-tests were carried out to determine the difference between the awareness with and without visualization in people with optimism bias (Table 2). It was observed that participants recognize the area of rip currents better after visualization than without visualization. Similarly, they had a stronger intent to avoid rip currents than those without visualization. There was no significant difference in the degree of perceived danger.

Ⅷ. Correlation coefficients between each variable

Pearson's product moment correlation coefficients were calculated to examine the relationship between each variable (Table 3). As most people had never experienced drowning accidents, this variable was excluded from the analyses. The intention to avoid rip currents showed significant positive correlation with the understanding of rip currents, the recognition of the area of rip currents, and the degree of danger with visualization. Additionally, gender showed marginally significant positive correlations with the recognition of the area of rip currents and the intent to avoid rip currents without visualization.

Ⅷ. The result of hierarchical multiple regression analysis predicting the intent to avoid rip currents

Hierarchical multiple regression analysis was performed to predict the intent to avoid rip currents (Table 4). The following predictor variables were subsequently entered into the regression model: control variables (i.e., gender and understanding of the rip currents) in the first step, recognition of the area of rip current, and the intent to avoid rip currents without visualization in the second step, recognition of the area of rip currents, the degree of danger, and the intent to avoid rip currents with visualization in the third step. In the third step, a positive relationship was observed between the understanding of rip currents, the recognition of the area of rip currents with visualization, and the intent to avoid rip currents with visualization. The coefficients of determination (R^2 s) and their increase (ΔR^2) except ΔR^2 in the second step, were significant in each step ($ps < .01$), and no multicollinearity was found between any predictor variables [variance inflation factor (VIF) = 1.00-1.55].

Discussion

Ⅷ. Knowledge of the beach and rip currents

Previous studies have reported that most beachgoers misidentified the area of rip currents when they were shown pictures and asked to identify the area of rips (Caldwell et al., 2013; Brannstrom et al., 2014; Houser et al., 2017). In this study, participants were asked if they knew what rip currents are, and if they knew about them, they were asked to offer an explanation through a free description. Fifty-three participants (58.9%) answered, "not understand" regarding their understanding of rip currents. This implied that more than half of them did not understand the phenomenon. Although there are differences in survey methods, the results of this study are similar to those of previous studies, which implies that more than half of beachgoers do not understand rip currents.

Ⅷ. The possibility of optimism bias for rip currents

People generally assume that "It won't happen to me," when fear is inadequate, and that they are safe from a particular risk (Slovic et al., 1981, 1987). Most people are not afraid of drowning as swimming is a low fear activity with known risks (Slovic et al., 1981, 1987; Sandman, 1989). Therefore, even if the danger of rip currents is pointed out, the danger perceived is likely to be underestimated due to the optimism bias. Additionally, studies have not been conducted on the impact of optimism bias in the

perception of rip currents. We investigated if participants display optimism bias for rip currents based on a set criterion. It was observed that more than half of the participants rated the possibility of others getting caught in rip currents as higher than their own, and this implied the existence of optimism bias. Therefore, it is necessary to examine the danger of rip currents while taking optimism bias into consideration.

II. Avoidance tendency after visualization of rip currents

Hatfield et al. (2012) and Houser et al. (2017) suggest that when beachgoers are given sufficient visual information about where rip currents occur, they can identify the area. Endo et al. (2019) reported that more than 90% of beachgoers who had visual information tried to avoid the areas of the rip currents. This study compares the perception of the area of rip currents, the degree of danger, and the intent to avoid rip currents with and without visualization rip currents in participants with optimism bias. The results indicated that the visualized phenomenon was significantly more likely to perceive and avoid rip currents than the non-visualized phenomenon. Therefore, the results of this study support previous studies and it is established that visualization of rip currents increases the intent to avoid them even if optimism bias exists.

Morgan, Ozanne-Smith, and Triggs (2009) reported that gender, age, alcohol consumption, overconfidence in swimming ability, and lack of knowledge about rip currents, were associated with drowning accidents due to the phenomenon. In this study, gender and frequency of going to the beach showed significant positive correlation with the recognition of the area of rip currents and the intent to avoid rip currents without visualization. Therefore, in the case of non-visualization, attributes such as gender and frequency are related to the intent to avoid rip currents as has been established in previous studies, and it is considered that this can lead to drowning accidents. On the other hand, the intent to avoid rip currents with visualization is not related to the above-mentioned variables, and the intent to avoid rip currents with visualization is positively related to the understanding of rip currents, the area of rip currents in the visualization, and the recognition of the danger. It is assumed that the results of this study reflect that everyone can recognize the area of the rip current after visualization, regardless of gender and frequency.

To prevent drowning accidents due to rip currents, previous studies have focused on placing warning signs, lifesaving surveillance, and beach flags, to indicate the safe swimming areas, or rip currents and other hazards (Ménard et al., 2018). However, studies that have evaluated the effectiveness of signs suggest that less than half of the beachgoers are not aware of signs posted on the beach (Matthews, Andronaco, & Adams, 2014; Brannstrom et al., 2015; Kaminski et al., 2017). It has also been suggested that many people did not prepare for or avoid rip currents, even if they were aware of the warning signs (Siegrist & Gutscher, 2006; Karanci, Aksit, and Dirik, 2005; Hall & Slothower, 2009). The results of analyses suggest that even those with optimism bias could avoid rip currents significantly by visualizing them. A hierarchical multiple regression analysis using the intention to avoid rip currents as a dependent variable showed a significant positive relationship with the recognition of the area of rip current after

visualization. Therefore, the results of this study suggest that visualizing the rip currents may increase the intent to avoid the area and thus plays an important role.

Previous studies have emphasized on educating people to deepen the understanding of rip currents (Hatfield et al., 2012; Endo et al., 2019). As has been mentioned above, half of the participants did not understand the phenomenon. The analysis suggests that the understanding of rip currents is positively related to the intent to avoid rip currents after visualization. Therefore, it is necessary not only to enhance the avoidance tendency by simply visualizing the rip currents, but also to further enhance education to deepen the understanding of the phenomenon including the danger and avoidance strategies.

Conclusion

This study investigates if visualization of rip currents could assist in preventing drowning accidents, considering the effects of optimism bias. The results of the analyses suggest that even if optimism bias exists, the visualization of rip currents increases the tendency of beachgoers to recognize and avoid rip currents. As described above, it has been observed that after visualizing rip currents, beachgoers can avoid them. However, this study is limited to data from only one beach and the conventional measures to prevent drowning by rip currents have not been compared. In future, it is necessary to conduct similar surveys at various beaches and compare them with conventional measures against drowning to clarify the effectiveness of visualization and to develop strategies to prevent of drowning accidents.

Declarations

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Tables

Table 1. Sample characteristics in terms of frequency, experience of a drowning accident, prior information gathering, swimming ability, and understanding of the rip current.

Item	Response	<i>n</i> (%)
Frequency	Infrequency (fewer than 10 times in my life)	24 (26.7)
	Once every year typically on vacation	37 (41.1)
	Multiple times per year	20 (22.2)
	Several times per year	4 (4.4)
	Frequency (weekly or daily)	5 (5.6)
Experience of a drowning accident	No experience	85 (94.4)
	Experienced	5 (5.6)
Prior information gathering	No	44 (48.9)
	Yes	46 (51.1)
Swimming ability	Unable to swim	11 (12.2)
	Weak swimmer	17 (18.9)
	Competent swimmer	35 (38.9)
	Highly competent swimmer	27 (30.0)
Understanding of rip currents	Not understand	53 (58.9)
	Understand	33 (36.7)
	Very understand	4 (4.4)

Table 2. The differences of awareness of rip current between without visualization and with visualization

Item	Without visualization	With visualization	<i>t</i> (<i>df</i>), <i>p</i> -value, Cohen's <i>d</i>
	<i>Mean</i> (<i>SD</i>)	<i>Mean</i> (<i>SD</i>)	
Cognition	7.62 (19.98)	52.38 (34.16)	<i>t</i> (62) = -9.88, <i>p</i> < .001, <i>d</i> = 1.60
Danger	70.00 (29.13)	68.89 (27.89)	<i>t</i> (62) = 0.28, <i>p</i> = .781, <i>d</i> = 0.04
Avoidance	28.10 (29.45)	61.75 (33.34)	<i>t</i> (62) = -6.91, <i>p</i> < .001, <i>d</i> = 1.07

Table 3. Correlation matrix for variables

	2	3	4	5	6	7	8	9	10	11	12
1. Gender	-.28*	.31*	-.36**	.38**	.04	.22	-.03	.37**	.02	-.08	.21
2. Age		-.06	.25*	-.35**	.42**	.27*	.27*	-.23	.10	.07	.06
3. Frequency			.01	.13	.05	.22	.09	.38**	-.05	.11	.03
4. Information				-.28*	.35**	.06	.22	-.06	-.10	.20	.08
5. Swimming					.13	.10	.01	.27	-.12	-.11	.002
6. Understanding						.31*	.39**	.06	.10	.15	.33**
7. Cognition (WV)							.22	.49**	.20	.12	.22
8. Danger (WV)								.12	.09	.39**	.10
9. Avoidance (WV)									.12	.17	.25
10. Cognition (V)										.55**	.47**
11. Risk (V)											.34**
12. Avoidance (V)											

Note. ** $p < .01$, * $p < .05$; WV: without visualization; V: with visualization.

Table 4. Hierarchical multiple regression analysis predicting avoidance (V)

Independent value	Avoidance (V)					
	R^2	ΔR^2	B	$SE B$	β	$F Model (df_1, df_2)$
Step 1	.15					5.15 (2, 60)**
Gender			13.40	7.90	.20	
Understanding			22.57**	8.48	.32	
Step 2	.17	.03				3.05 (4, 58)*
Gender			9.01	8.53	.14	
Understanding			21.98*	8.97	.30	
Cognition (WV)			0.004	0.24	.002	
Avoidance (WV)			0.20	0.16	.18	
Step 3	.36	.18**				5.20 (6, 56)***
Gender			10.90	7.78	.17	
Understanding			19.78*	8.13	.28	
Cognition (WV)			-0.11	0.22	-.07	
Avoidance (WV)			0.16	0.15	.14	
Cognition (V)			0.38**	0.13	.39	
Danger (V)			0.10	0.16	.08	

Note. *** $p < .001$, ** $p < .01$, * $p < .05$; WV: without visualization; V: with visualization

Figures

Figure 1

The place of this study (Aoshima beach)

Figure 2

The image that we explained rip currents

Figure 3

The image in the case of visualization of rip currents