

Effect of Conditioned Stimulus Generalization on Regression of Fear Memory Fading

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Abstract. The overgeneralization is deemed as one reason for the fading training failure and causes the regression of the fear memory or addiction memory. The study adopts prediction for the task judgment and observes the effect on the fear memory fading from the change of overgeneralization stimulus characteristics through changing the conditioned stimulus color, shape and size. The result shows that the fading regression quantity in the size generation group and the control group is the minimum and the fading generation in the color and shape generation is the most obvious. It shall avoid the occurrence of similar clues of the color and shape like the conditioned stimulus to the greatest extent during the treatment process based on the memory fading training in the future and therefore improve the fading training effect on the treatment of pathological memory such as the addiction memory and traumatic memory, etc.

1. Introduction

The generalization is defined extremely widely in the psychological study, among which, the most popular definition is the study generalization phenomenon of study theories under Pavlov classical conditions (Pavlov, 1972). Under the classical condition influence, the single display of CS also may result in the individual conditioned response (hereinafter referred to as “CR”) same to the unconditioned response (hereinafter referred to as “UR”) after several displays of the conditioned stimulus (hereinafter referred to as “CS”) and unconditioned stimulus matching (hereinafter referred to as “US”) and after a while, the individual may have the similar response for the generalized stimulus (hereinafter referred to as “GS”) of CS. As the generalization is the long-term evolution process outcome and will always occur to a certain extent for the individual during study, the existence of such phenomena may cause the individual to have the similar response for the potential thing of the same result (such as people will be alert to snakes after the experience of bite by one snake of one species) and the generalization is one adaptation phenomenon from the evolution aspect. The normal adaptive generalization produces lots of benefit for the individual, which includes helping the individual to classify the stimulus and situations, improve the study efficiency, improve the reaction speed for the stimulus, save energy and pay attention to resources. For the fear experiences, the generalization may protect people from bad consequences caused by stimulus similar to danger signals and help the individual to predict the possible consequence of clues based on the experience (McLern & Mackintosh, 2002).

However, the fear overgeneralization may bring about adverse impact and become an important reason for lots of fading training failure. The overgeneralization may cause the individual to transfer

clues acquired under the situation condition effects (Flor & Wessa, 2010; Garner et al., 2012) into the safe environment or generate irresistible abnormal act and emotional response (such as the continuous anxiety response of the generalized anxiety disorder) even if such individual is capable of identifying the new situation and that causing the improper reaction definitely (Woody & Rachman, 1994); or the addict as deemed successful withdrawal after the successful fading training, reenter into the similar environment or situation and have the fading regression phenomenon of the addiction memory and therefore the addiction relapse. Therefore, the ways to reduce the fading regression of the fear memory and addiction memory through effective fading training become the focus of recent research. The memory fading training is based on Pavlov's conditioned memory and the previous research always realizes the purpose of fading regression reduction through changing CS property during the fading training or the interval between CS and US and so on. But the way for the generalization influence on the memory fading is still the dispute focus of lots of research. Based on Pavlov's opinions, the overgeneralization result is that the individual produces the response same to that of US for CS generalized stimulus, and the physical characteristic with the most intense influence on the fading and similar to CS has the practical instruction sense for the memory fading training. Brune et al. proves through tests that there exists the generalization effect in the case where the vision mixes with hearing and the difference between the generalization stimulus characteristics and the conditioned stimulus characteristics is not especially obvious (such as the color is the red, yellow, blue and green and the shape is round). The previous research on generalization always puts the conditioned stimulus as a whole and omits the stimulus formation of various characteristics, which may exist independently in the memory and link the neutral stimulus and aversive stimulus US. If one red triangle and the scream form CS and cause the fear response, which is the reason for the fear among the color, triangle, or the whole formed? Such problem involves the fear generalization transfer character. In the research, Zhu Jingfang uses Ekman fear expression for the conditioned acquisition and fading. She uses 125% generalization stimulus of the fear expression to fade 75% conditioned stimulus and obtains the better fading result than that obtained through the original conditioned stimulus, which proves that the higher the related characters are, the better the result for the memory fading will be.

As the good memory fading is not equivalent to the absence of the fading regression phenomenon, it shall pay more attention to ways to reduce the fear memory and addiction memory fading regression phenomena and realize substantially the fear memory removal and addiction withdrawal. At present, the majority of research related to the fading regression focuses on the renewal effect. The so-called renewal effect means that if one individual acquires the fear response in one kind of environment (such as the supermarket) and obtains the exposure therapy in the different environment (such as in the counselor's office), then such individual may re-generate the fear response upon re-entrance into the initial environment for the fear acquisition or the brand-new environment. It is concluded from some research that some perceptual characters (such as the shape, size and color) may influence the fading regression effect and the fading regression is the outcome of the environmental factors and perceptual characters above. There is also some research about the fear generalization influence on the fading regression. Bram finds in the research that the fear regression will also occur during the test phase if a sized-changed stimulus is used for fading (the acute triangle is changed into the obtuse angle). But there is little research about the fear memory fading regression through changing various perceptual characters of the conditioned stimulus.

Based on the generalization theory (Nosofsky, 1991), the importance of one dimension is influenced by the classification and identification thereof. Therefore, the generalization effect may increase as the similarity between the object and the template increases. However, the problem

interested by the research is to define dimensions whose characters have significant influence on the fading regression after the generalization fading. Therefore, it shall try to take some characters from the conditioned stimulus out as independent clues (color, shape and size), which will be used as the conditioned stimulus of the generalization fading, and study which clue character is prone to cause the fear memory fading regression through comparison of the generalization regression process and the fading regression process.

2. Research method

2.1 Subjects

In this experiment, 75 college students were recruited to be as subjects, who participated in a voluntary registration way, and would get a certain reward after the completion of the experiment, as well as signed an informed consent before the experiment. Subjects in the experiment had normal visual acuity or corrected visual acuity, no hearing loss, no physical illness and mental disorders. Subjects were randomly assigned to 4 groups (control group, color generalization group, shape generalization group and size generalization group), all groups had 19 people except color group had 18 people. Aged 18 to 22 years ($M = 20.32$, $SD = 1.78$). There was no significant difference between the two groups tested by State-Trait Anxiety Inventory (STAI) ($F(3) = 0.09$, $p > 0.05$).

2.2 Materials

The materials were described in stages. **Acquisition Stage**, the experiment used geometric figures as the conditioned stimulus(CS), respectively, yellow triangle and red circle, the two shapes had the same brightness, the background was white, rendering time was 8000 ms, in which, the yellow triangle would fixedly follow US as CS +, while the red circle would never follow US as CS-. Referring to the study of Jackson, Payne, Nadel and Jacobs (2006), this experiment used a woman's scream as US to induce the fear of the subjects. The sound was selected from China's Emotional Sound Library (Titer $M = 2.04$, $SD = 0.89$; Arousal $M = 7.60$, $SD = 1.08$), the duration was 3000ms; sound intensity showed in the experiment was 100dB level.

Extinction Generalization Stage in control group, extinction stimulus was yellow triangle and red circle, the same as stimulus in Acquisition Stage. In color generalization group, GS+ was blue triangle, and GS- was orange circle. In shape generalization group, GS+ was yellow parallelogram, and GS- was red oval. In size generalization group, GS+ was 85% of the size of the yellow triangle, and GS- was 85% of the size of the red circle.

Test Stage The presented shapes were consistent with the stimulation of Acquisition Stage.

2.3 Experimental Procedures

All the stimulus and pictures were presented through Eprime ~ 1.2 programming. For each trial of the experiment, first appeared the fixation point "+", with rendering time of 1000 ms (shown in Figure 1), appeared CS after the fixation point, with rendering time of 8000 ms, then followed by a detection interface, which required the subjects to perform 1 to 7 keys response to judge the possibility of the emergence of US, 1 stands for the forecast that there is certainly no screams, 7 stands for the forecast that there must be screams appearing. After the reaction it would appear blank screen, CS + would have 3000ms of screams. Finally 3000ms of blank screen was buffering.

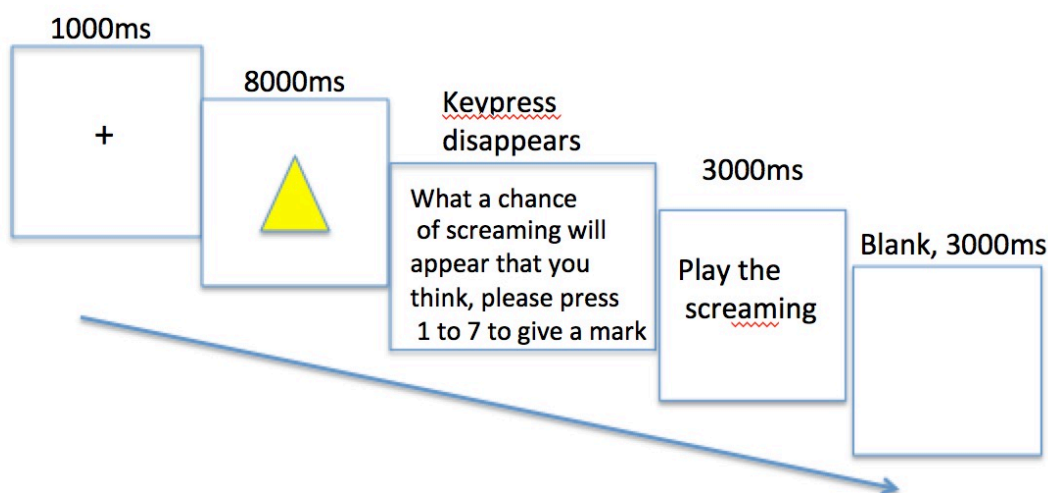


Figure 1 Trial in Acquisition Stage

This experiment consists of three stages, namely, acquisition stage, generalization extinction stage and test stage. Before the acquisition stage, it was filled in the Trait Anxiety inventory. Took a rest for half a minute between acquisition stage and generalization extinction stage, took a rest for 15 minutes between generalization extinction stage and test stage, filled in STAI during the period. Asked the subjects to be quiet in the course of rest and avoid strenuous activity. Before acquisition stage, habitual practice was performed in experimental process, CS + and CS- in habitual stage appeared three times. After the practice was completed, the subjects entered the Acquisition Stage.

In acquisition stage, Trial of two kinds of stimulation, namely CS+ and CS-, appeared four times separately, CS+ would fixedly follow screaming (US) after the keypress reaction, while CS- wouldn't follow US after the keypress reaction. Order of appearance of CS + and CS- cancelled each other in the group (that is, in the same experimental group, half of the people first presented CS + then presented CS -, otherwise normal people first present CS- then present CS +, so it is in the same way in the next two stages), his is because the Lovibond study found that a CS + or GS + stimulus without US would affect the reaction of CS- or GS- presented subsequently.

Extinction stimulus in control group in generalization extinction stage, was consistent with CS + and CS- in acquisition stage, separately appearing four times. In color generalization group, shape generalization group and size generalization group, GS + and GS- appeared four times separately, and no two appeared consecutively.

In test stage, all five groups would present CS + and CS- presented in acquisition stage separately for three time. US would not appear in generalization extinction stage and in test stage.

3. Results

3.1 Acquisition Stage

For data in Acquisition Stage, took stimulus type(CS+ / CS-) and trial (4 levels of acquisition stage and 4 levels of extinction stage) as internal factors of the subjects, groups (4) were the factors between the subjects, carried out repeated ANOVA of 4 (Group) × 2 (CS) × 4 (Trial). The main effect of conditional stimulation (CS) was significant, $F(1, 71) = 1496.75, p < 0.001, \eta^2 = 0.64$. The interaction between conditional stimulation (CS) and Trial was significant, $F(3, 213) = 365.98, p < 0.001, \eta^2 = 0.80$. The interaction between groups and stimulus and Trial was not significant, $F(9,$

639) = 0.85, $p > 0.05$. It shows that in Acquisition Stage, the expected value of CS + will increase with the increase of trial times, the trend of each group is the same and the difference between groups is not significant (as shown in Figure 2).

Carried out repeated ANOVA of 4 (Group) \times 2 (CS) for the last Trial of CS+ and CS-, the mean predictive value of CS+ ($M = 6.67$, $SD = 0.72$) was significantly higher than that of CS- ($M = 1.07$, $SD = 0.26$), $F(1, 89) = 5106.92$, $p < 0.001$, $\eta^2 = 0.59$. The interaction between groups and CS was not significant, $F(3, 213) = 0.58$, $p > 0.05$. It shows that at the end of acquisition stage, the expected value of CS+ is higher than that of CS-, and there is no difference between groups, indicating that the acquisition process is successful.

3.2 Generalization Extinction Stage

Except in the control group, the other groups compared the last Trial of acquisition stage with the first trial of generalization extinction. Carried out repeated ANOVA of 3 (Group) \times 2 (Trial) for expected value of CS+ and CS-, the main effect of Trial is not significant, $F(1, 53) = 2.02$, $p > 0.05$. The interaction between Trial and Groups was not significant, $F(2, 53) = 1.20$, $p > 0.05$. It shows size generalization group, shape generalization group and color generalization group were all generalized successfully.

Carried out repeated ANOVA of 4 (Group) \times 2 (GS) \times 4 (Trial) for changes in the expected values for each group in Generalization Extinction Stage. The main effect of generalization stimulus was significant, $F(1, 71) = 347.80$, $p < 0.001$, $\eta^2 = 0.83$. The interaction between generalization stimulus and Trial was significant, $F(3, 213) = 39.62$, $p < 0.001$, $\eta^2 = 0.358$. The interaction between generalization stimulus and Trial and Groups was not significant, $F(9, 639) = 1.26$, $p > 0.05$. It shows that the expected value of generalization stimulus will decrease with the increase of extinction trial, and the difference in extinction change of the groups is not significant.

Carried out repeated ANOVA of 4 (Group) \times 2 (GS) for the first Trial of GS+ and GS-. $F(1, 71) = 344.52$, $p < 0.001$, $\eta^2 = 0.83$. And obviously GS+ ($M = 6.72$, $SD = 0.67$) is higher than GS- ($M = 2.91$, $SD = 1.61$). The interaction between groups and GS was not significant, $F(3, 213) = 1.81$, $p > 0.05$. It shows that the expected value of GS+ is higher than that of GS- at the beginning of generalization extinction stage.

3.3 Test phase

In the test phase, the expected value is analyzed by repeated measurement using 4 (Group) \times 2 (CS) \times 3 (Trial). The main effect of CS is remarkable, $F(1, 71) = 335.06$, $p < 0.001$, $\eta^2 = 0.79$. The main effect of Trial is remarkable, $F(2, 142) = 96.83$, $p < 0.001$, $\eta^2 = 0.52$. As the test increases, the expected value decreases. The interaction between groups and CS is significant, $F(3, 213) = 3.35$, $p < 0.05$, $\eta^2 = 0.31$. By simple effect analysis, the difference between CS- group is not significant ($F(4) = 0.24$, $p > 0.05$), and the difference between CS+ group is significant ($F(4) = 28.06$, $p < 0.001$). It shows that the expected value of CS+ is greater than that of CS-. Color generalization and shape generalization group have the highest expected value.

Observe after the generalization extinction phase, whether the original stimulus in the test phase can cause the fear to return. In the control group, the final CS+ expected value in extinction phase ($M = 3.79$, $SD = 1.23$) is higher than of in the test phase ($M = 2.95$, $SD = 1.22$), $t(18) = 3.15$, $p < 0.001$. In the color generalization group, the CS+ expected value ($M = 2.22$, $SD = 1.44$) of the first Trial in the test phase is higher than the final GS+ ($M = 6.22$, $SD = 0.81$) of the extinction phase, $t(17) = 11.35$, $p < 0.001$. In the shape generalization group, the CS+ expected value ($M = 3.00$, $SD = 1.60$) of the first Trial in the test phase is lower than the final GS+ ($M = 5.95$, $SD = 0.97$) in the extinction phase, $t(18) = 5.59$, $p < 0.001$. In size groups, the difference is not significant between

CS+ the first Trial expected value ($M = 2.63$, $SD = 2.63$) in the test phase and CS + the first expected value ($M = 3.21$, $SD = 1.03$) in the descending phase, $t(18) = 1.93$, $p > 0.05$. It shows that there is an extinction of the fear memory in the color generalization group and the shape generalization group after the generalization subsided but it doesn't appear in the size group and control group.

A single factor variance analysis is conducted for the expected value and the average value of CS+ in the test phase. The main effect of the groups is significant, $F(3, 89) = 18.84$, $p < 0.001$, $\eta^2 = 0.46$. The result shows that the color generalization group ($M = 4.44$, $SD = 0.82$) and the shape generalization group ($M = 4.61$, $SD = 1.29$) have the highest predictive value in the test phase. The difference between the two groups is not significant, $t(2) = 0.55$, $p > 0.05$. That is significantly higher than the size generalization group ($M = 2.51$, $SD = 0.85$), $t(2) = 9.17$, $p < 0.05$ and the control group ($M = 2.46$, $SD = 0.81$). The two groups with the best extinction are the control group and the size generalization group. The difference is not significant, $t(2) = 0.18$, $p > 0.05$.

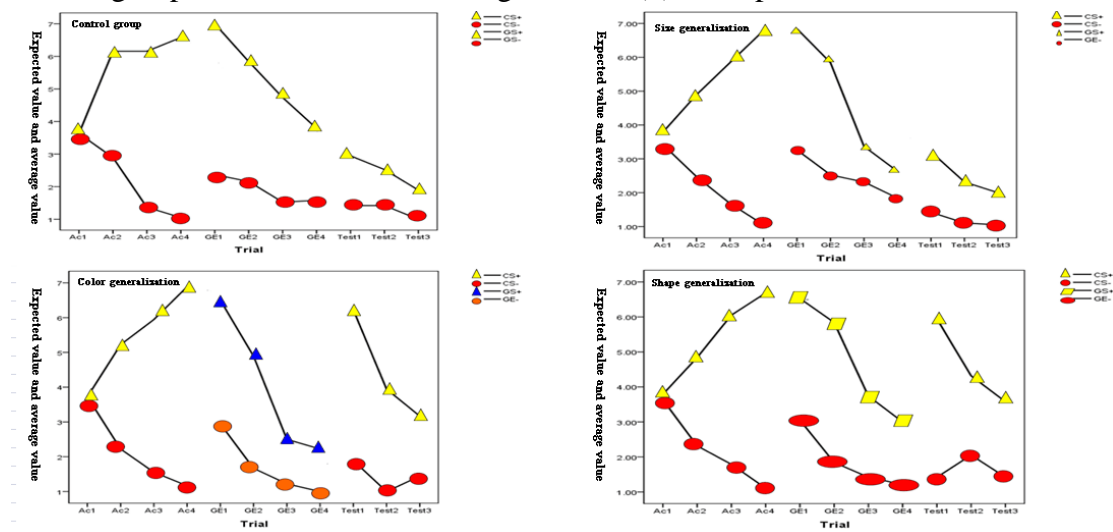


Fig. 2 Changes of expected value and average value of stages of each group

4. Discussion

The purpose of this experiment is to examine the effects of generalization extinction on the extinction process and extinction return of fear memory. In the process of generalization extinction, the test of each group is successful and the difference is not significant. In the extinction return test phase, color generalization and shape generalization appear to be more significant than the control group and the size generalization group. This suggests that in the course of regression training, the relevant clues like conditioned stimulus similar colors and shapes are avoided, which can greatly reduce the effect of extinction and induce the extinction return of the fear memory.

4.1 Generalization extinction process

In generalization groups, the generalization stimulus is not recognized in the absence of obvious difference between CS+ and GS+ (Bouton & Burr, 2002). The subjects converge on the CS features and scream US. Each group succeeds in generalization, and the change of a physical feature of the conditioned stimulus does not reduce the expected value of the fear stimulus, but still evokes the memory of the fear. Similar to Schmidt's and De Houwer's research (William, 2012), through the acquisition phase, even if there is no special instruction to classify the color, shape, and size of the CS, the participants automatically categorize the various features of CS. The results

show that the stimulation of CS+ features such as size, shape and color can easily cause the generalization of acquisition memory. Successful generalization is not only a reflection of the learning ability of human society, saving resources for human beings but also brings about some adverse effects. For patients with anxiety disorder and addiction memory, it is easy to generalize the memory of CS+ similar stimulation, and avoid the occurrence of CS+ similar clues in the treatment process, which can reduce the flashback of negative memories.

Different from Vervliet's study, the difference between CS+ (GS+) and CS- (GS -) is more significant in this experiment in acquisition phase and the generalization phase extinction. Therefore, during the generalization extinction process, the test can distinguish the "CS +" graphics and "CS -" graphics better. In Vervliet's experiment, there is only one characteristic difference between CS + and CS - in generalization extinction, as in color group CS + is a yellow triangle, and CS - is a red triangle. When GS is a blue triangle and a yellow square in the generalization extinction phase, the test cannot differentiate whether there are dangerous clues in blue triangle, therefore it fails to generalize. According to the results of this study, there are two important conditions for successful generalization extinction. The difference between CS+ and CS- and GS+ and GS is very important to the success of the generalization extinction. The difference is too small to cause generalization. The difference between the conditioned stimulus CS+ and the generalization stimulus GS+ can not be too large; it is too large to cause generalization. This result shows that the effect of the extinction training is similar to the characteristics of CS+ and the characteristics of CS, which can guarantee the effect of generalization extinction. However, after the generalization extinction, the results of extinction return will be further explored to check that what kind of characteristics of GS+ has the greatest influence on negative memory.

4.2 Generalization and fading regression

In the fading regression phase, the control group and size group have the smallest-extent negative memory regression and the color group and shape group have the worst result. The color and shape generalization groups are same to the prediction and have the largest-extent fading regression and comply with the prediction. However, the regression result of the size group is better than that of the multiple generalization group and is same to that of the control group, which is not discovered by the previous research and is one innovation aspect of the research.

It's unanimous to explain how the generalization regression fading process emerges, through which, a memory template will emerge through acquisition of the stimulus characters and the generalization will emerge as stimulus is similar to the template; but it's divergent for understating the generalization fading process. Through combination of the grasp of the generalization fading process by previous researchers (such as the new template theory for fading and the integration mechanism and identification process), it's concluded from the research that the fading process may produce the new fading template, such process is also an identification process and the difference between two templates upon comparison between the new template and the original stimulus may cause the fear regression of different levels. This also explains why the fading result through adopting AB for fading exercise is better than that of adoption of element A, which is the research result of Bouton et al. in the previous; and also explains why the fading regression of the color and shape generalization groups is the most obvious (excluding the reasons why the fading regression of the size generalization group is little) in the research. It will analyze specially the fading result of each generalization character in the following content.

After the acquisition stage, the control group in the experiment forms the template through the trial of CS+ characters acquisition and still has the relatively-high predicted value for CS+ through

the first two trials in the fading stage. It forms a new template for CS+ through the trial after no US occurs through four trials in the fading stage and such template is same to that in the test stage and no relatively-high fear regression occurs therefore. The result above is same to that of the research by Bouton et al. The fading regression quantity is extremely low after the fading training through adoption of the same clues, but the life clue analogue is inevitable and the generalization regression will be analyzed in the following content therefore.

The fading effect difference between the size group and the control group is not obvious. The size group generalization stimulus provides two clues same to the original stimulus with the only difference of the stimulus size. It's proved through Lissek research that it's impossible to identify the generalization stimulus if smaller than 15% of the original stimulus among the healthy people. As the generalization stimulus and the original one fail to occur in succession in the research, it's possible that the generalization stimulus is deemed as the original one and the size clues are no longer the characters of the new template formation therefore. In the fading stage, it forms the new template through the generalization stimulus shape and color through trial without the size identification. Therefore, the fading result difference with the control group in the trial stage is not significant. As the size as one physical character only become detective by the human perception through comparison with the contrast, it may be concluded that the size change identification is not as easy as that of the shape and color changes, which complies with the theory that the fading process is an identification one in the previous research.

In the color and shape groups, the generalization stimulus only changes one character of the original conditioned stimulus and the fading effect thereof is the lowest among all groups. During the generalization fading process, the new template formed only has one character same to that of the original stimulus. As the original conditioned stimulus re-occurs in the trial stage, the fading effect obtained is relatively low as the template formed during the generalization fading process is separated from most original conditioned stimulus. At the same time, it also suggests that the stimulus with the shape and color similar to those online is prone to cause the fear memory fading regression, for which, it shall prevent the occurrence of such two kinds of stimulus to the greatest extent during the fading training and improve the fading training effect therefore.

The research, as different from Shmuel Lissek research placing the graph size change as the generalization gradient, isolates each character of the graph for fading, through which, it's possible to grasp influence on the fading and fading regression progress from each character of the stimulus definitely. In the previous research, it always explains the acquisition and fading processes through separation of the character acquisition (Rescorla,1976), templates theories (Logan,2002), fading identification (William, 2012) and conditioned stimulus whole and elements (Mark, 2012); however, the research tries to integrate those theories above into one comprehensive theory. In the acquisition process, it conducts classification through the acquisition characters and the new stimulus will be generalized under the case where no obvious difference occurs between two stimuli upon the reoccurrence of same characters. In the fading process, it acquires the safety characters in the generalization fading stimulus and forms the new template, which will be differentiated and compared with the original stimulus.

The practical significance of the research is that it shall pay sufficient attention to the characteristic (namely the relevant color and shape changes of the conditioned stimulus clues are prone to cause the generalization and the fading regression therefore) and avoid the occurrence of similar clues in the environment or background during the therapy for the anxiety and addiction related problems based on the memory fading exercise. Simultaneously, for the characteristic that it's hard to produce generalization for stimuli of different size through trial, it shall restore the

acquisition scene to the greatest extent or simulate a scaled-down scene in the fading training process, which is beneficial to the fear memory flashback and guarantees the therapy effectiveness.

5. Deficiency and prospect

The research is conducted based on previous research and studies the fading through taking the shape, color and size as independent characters, which are different from that of the previous research.

6. Conclusion

In the early stage of the generalization fading, it realizes the generalization for each group successfully through changing the color, shape and size of the conditioned stimulus.

In the generation fading, it may realize the generalization fading for each group successfully after the fading training through changing the color, shape and size.

In the trial stage, the best fading result occurs in the control group adopting the original conditioned stimulus for fading and the size generalization group narrowing to 85% of the original one; the fading regression occurrence with the largest possibility is in the color and the shape generalization groups with the only change of the color or the shape.

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