1. INTRODUCTION

Curiosity is a basic drive of exploration [1]. As such, curiosity has been studied in a variety of areas in design and engineering such as interface design [2], gaming [3], instructional environment design [4] and robotics [5, 6].

1.1 Diversive curiosity and specific curiosity

The foundation of present psychological study on curiosity was provided by Berlyne [7]. Berlyne has divided exploration into diversive exploration and specific exploration. In diversive exploration people explore information widely without specific target. By contrast in specific exploration people explore to fill specific information gap.

According to Berlyne [7], diversive exploration arises in a low arousal or boring state to increase arousal to an intermediate level where people supposedly feel most pleasant. By contrast specific exploration arises in a high arousal state caused by confusing stimuli. People try to decrease the unpleasant high arousal to an intermediate level by clarifying confusion with specific exploration. Although, there still remain controversies about Berlyne’s explanation based on arousal level, the distinction between diversive exploration and specific exploration is well established [8, 9].

Because, exploration and drive are the basic components of curiosity, diversive exploration and corresponding drive make up specific curiosity. Diversive curiosity and specific curiosity are the basic paired types in epistemic curiosity [8, 9]. Berlyne [7] also formulated the characteristics of stimuli which induce curiosity. These are novelty, complexity, uncertainty and conflict. These four properties of stimuli are called collectively as collative variables.

1.2 Trait curiosity and the appraisal structure of state curiosity

After Berlyne’s pioneering work, two lines of notable progress were made in the psychological study of curiosity [8, 9].

One line of progress is the development of several scales to measure individual differences shown in person’s everyday behavior concerning curiosity or person’s trait curiosity. A representative scale is epistemic curiosity scale which measures diversive curiosity and specific curiosity in epistemic (knowledge) behavior [10].

A few measures of state curiosity were also developed [8]. The state trait concept is a basic distinction in emotion psychology [11]. For example state anxiety indicates how much you feel anxiety at the present moment. In contrast trait anxiety indicates how much you feel anxiety usually. In the same way, the state curiosity indicates how much you feel curiosity at the present moment. Trait curiosity indicates how much you feel curiosity on average.

As mentioned above, second line of progress is made in the area of emotion psychology. Emotions are multifaceted

NOTE

Effects of Trait Curiosities on the Appraisals of Picture Stimuli: Diversive Curiosity and Specific Curiosity

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Abstract: Affective designs need to take into account the existence of considerable individual differences in people’s emotions. In this study, individual differences in appraisal structure of knowledge emotions were addressed. Participants viewed puzzling and intriguing pictures and rated their unintelligibility and consequential feelings of interest and confusion. Rather large individual differences in the relations between unintelligibility appraisals and ensuing knowledge emotions of interest and confusion were found. These individual differences of appraisals were shown to be related to individual differences in trait curiosities by multi-level analysis. On average people with high trait diversive curiosity have tendency to feel more interest when they found pictures more unintelligible. By contrast people with high trait specific curiosity have tendency to feel more confusion when they found pictures more unintelligible.

Keywords: Curiosity, Appraisal, Multilevel modeling

and corresponding drive make up specific curiosity.
phenomena comprised of cognitive appraisal, feeling and drive or behavioral tendency [11]. Silvia [8] has analyzed the appraisal structure in the present experience of curiosity or state curiosity. In reference to Berlyne’s collative variables, Silvia [8] emphasized the importance of complexity/novelty and understandability in the appraisal structure of curiosity. According to Silvia [8], the joy as a feeling of curiosity will ensue after the appraisals of complex and novel stimuli as understandable.

Based on these two lines of studies, Silvia [12, 13] has begun to analyze the effect of trait curiosity on the appraisal structure of state curiosity using multilevel modeling analysis.

1.3 Aims of present study
People may differ significantly in the appraisal structure of emotions [14]. This rather newly emerged problem in emotion psychology is important to affective design for people [15] and affective engineering in general. Present study was a tentative attempt to analyze the effect of trait curiosities on the appraisal structure of state curiosity. Although the basic scheme of the study was same to Silvia [12, 13], we measured trait diversive curiosity and trait specific curiosity separately and tried to compare their effects on appraisal structure of state curiosity.

2. METHOD

2.1 Participants
A total of 70 students with an average age of 20.5 - 48 women, 22 men - enrolled in general psychology at a University in Osaka participated. All participants spoke Japanese as a native language.

2.2 Procedure
All participants answered two questionnaires. First questionnaire was a picture rating booklet, which consisted of 20 sheets. Second questionnaire was a trait epistemic curiosity scale, which consisted of 12 items [16].

2.3 Instrument
Picture stimuli rating booklet. Each sheet of the booklet consists of a picture and rating items about the picture. These are puzzles, illusions, trick arts and unnatural scenes, which were selected to arouse state curiosity. Rating items are constructed from three subscales. These are unintelligibility, vagueness and joy. Items of unintelligibility are “can’t make out the nuts and bolts”, “can figure out the mechanism (reverse item)” and “can’t understand the mechanism”. Items of vagueness are “feel vague” and “get confused”. Items of joy are “feel amusing” and “get excited”. Participants were asked to rate their feeling after viewing each picture on a 5-point Likert scale, ranging from 1 (not at all) to 5 (extremely).

Trait epistemic curiosity scale. This scale measures the trait epistemic curiosities of each participant based on the self-report of everyday behavior. Although the basic concept is the same to English version of epistemic curiosity scale [10], this scale was developed as an original Japanese epistemic curiosity scale to measure trait diversive curiosity and specific trait curiosity [16]. Trait epistemic curiosity scale contains two 6-item subscales: diversive curiosity (e.g., “I prefer to challenge new things”) and specific curiosity (e.g., “I am a person who think through till I get at clear answer”). Items are rated on a 5-point Likert scale, ranging from 1 (not at all) to 5 (extremely). Both subscales have enough reliability ($\alpha = .81$ for both subscales) and adequate validity which were shown in the relation to other basic measures [16].

2.4 Analyses
Among three subscales, vagueness and joy are feeling after viewing a picture. Joy is a positive feeling of state curiosity and vagueness is a negative feeling of confusion [17]. As suggested by Silvia [17], confusion can be classified as a knowledge emotion together with curiosity.

Unintelligibility is a lack of understandability or lack of coping potential in knowledge emotion [8]. In the emotion of confusion, the appraisal of stimuli as unintelligible will cause the feeling of vagueness. Intelligibility and unintelligibility is the appraisal of stimuli and vagueness and joy are the ensuing states of feeling caused by appraisal [8]. So we analyzed the data with emotional state of vagueness and joy as dependent variables and appraisal component of unintelligibility as an independent variable.

The relation between unintelligibility appraisal and emotion state of joy and confusion for 20 pictures can be analyzed individually. This regression analysis is a within participant level analysis. The regression of 70 participants at within participant level may differ in their intercepts and slopes. These differences of intercepts and slopes can be explained by parameters at inter participant level. We analyzed these differences of intercepts and slopes by inter participant differences in trait diversive curiosity and trait specific curiosity using multilevel analysis. Interclass correlation coefficients (ICC) of Joy scale and Vagueness scale were both .19 ($p < .001$).

Data analyses were conducted by M-plus version 7.3.
3. RESULTS AND DISCUSSION

Figure 1 shows regression lines of 70 participants with dependent variable of joy and independent variable of unintelligibility. As a whole slope of regression was negative ($\beta = -0.017$), but there exists a group of lines with distinct positive slope. Figure 2 shows regression lines of 70 participants with dependent variable of vagueness and independent variable of unintelligibility. As a whole slope of regression was positive ($\beta = 0.534$). Although there are individual differences in regression lines overall tendency of positive slope is rather consistent.

We analyzed these individual differences in relation between unintelligibility appraisal and emotion state of joy and confusion by multilevel analysis. Model-1 is a multilevel analysis equation for joy and Model-2 is a multilevel analysis equation for vagueness. Except for the difference in dependent variable at Level-1 two equations are identical. So here we annotate the terms in Model-1.

Joy$_j$ is a rating of joy in participant $j$. when viewing picture $i$. In the same way (Unintelligibility)$_j$ is a rating of unintelligibility in participant $j$ when viewing picture $i$. $\beta_{0j}$ and $\beta_{1j}$ are the coefficients of regression analysis at Level 1, where $\beta_{0j}$ is intercept and $\beta_{1j}$ is slope. $e_j$ stands for residual error of each regression.

In multilevel analysis, regression coefficients at state level vary between participants. These differences of regression coefficients are analyzed at Level-2. ($\text{Diversive curiosity}$)$_j$ and ($\text{Specific curiosity}$)$_j$ are the scores of trait curiosity in participant $j$. $\gamma_{00}$, $\gamma_{01}$ and $\gamma_{02}$ are the slopes of multiple regression analysis for $\beta_{0j}$, $\gamma_{00}$ is intercept and $E_{0j}$ stands for residual error of each multiple regression. In the same way, $\gamma_{11}$ and $\gamma_{12}$ are the slopes in multiple regression for $\beta_{1j}$, $\gamma_{10}$ is intercept and $E_{1j}$ stands for residual error of each multiple regression.

Model-1:
Level-1 : (State)
$$\text{Joy}_j = \beta_{0j} + \beta_{1j} \cdot (\text{Unintelligibility})_j + e_j$$
Level-2 : (Trait)
$$\beta_{0j} = \gamma_{00} + \gamma_{01} (\text{Diversive curiosity})_j$$
$$+ \gamma_{02} (\text{Specific curiosity})_j$$
$$+ \gamma_{03} (\text{Unintelligibility}) + E_{0j}$$
$$\beta_{1j} = \gamma_{10} + \gamma_{11} (\text{Diversive curiosity})_j$$
$$+ \gamma_{12} (\text{Specific curiosity})_j + E_{1j}$$

Model-2:
Level-1 : (State)
$$\text{Vagueness}_j = \beta_{0j} + \beta_{1j} \cdot (\text{Unintelligibility})_j + e_j$$
Level-2 : (Trait)
$$\beta_{0j} = \gamma_{00} + \gamma_{01} (\text{Diversive curiosity})_j$$
$$+ \gamma_{02} (\text{Specific curiosity})_j$$
$$+ \gamma_{03} (\text{Unintelligibility}) + E_{0j}$$
$$\beta_{1j} = \gamma_{10} + \gamma_{11} (\text{Diversive curiosity})_j$$
$$+ \gamma_{12} (\text{Specific curiosity})_j + E_{1j}$$

Table 1 is the result of multilevel analysis. All estimates are shown in unstandardized value.

In Model-1, the estimate of $\gamma_{01}$ was .216. With a standard error of .095, the regression weight was significant ($p < .05$). The estimate of $\gamma_{11}$ was .087. With a standard error of .031, the regression weight was significant ($p < .01$). These results revealed significant effects of trait diverive
Curiosity on the relation between unintelligibility appraisal and joy. On average people with high diversive curiosity have a tendency to feel more joy when viewing pictures of this study. They also feel more joy when they found pictures more unintelligible. Concerning the feeling of joy, there were no significant effects of trait specific curiosity.

In Model-2, the estimate of $\gamma_{02}$ was .202. With a standard error of .087, the regression weight was significant ($p < .05$). This result means that, on average people with high specific curiosity have a tendency to feel more vagueness when viewing pictures of this study. The estimate of $\gamma_{03}$ was .960. With a standard error of .154, the regression weight was significant, ($p < .001$). This result means that, on average people who found pictures of this study more unintelligible have a tendency to feel more vagueness when viewing pictures.

This preliminary study revealed the existence of rather large individual differences in the appraisals of knowledge emotions such as state curiosity and confusion [17]. Some parts of individual differences were shown to be explained by trait curiosities. We have found that, when pictures are unintelligible, people with high trait specific curiosity feel more interest and people with high trait specific curiosity feel more confusion. To generalize these results, further studies using different stimulus set are in need.

People respond differently to the same stimuli. In this study it was shown that individual differences in two types of trait curiosity have different effects on knowledge emotions. Such individual differences should be taken into account in affective design [15]. Recent interface can learn from interaction with user. For example it was found that, a computer interface which imitates the individual differences in the response pattern of user was usually rated more preferable by the user [18]. Studies on the effects of individual differences in affective responses can contribute to make affective design more flexible to match each person’s need.

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**REFERENCES**

1. J. Panksepp, J. Biven; The Archaeology of Mind: Neuroevolutionary Origins of Human Emotions. WW Norton, New York, 2012.
2. S. P. Anderson; Seductive Interaction Design: Creating Playful, Fun, and Effective User Experiences. New Riders, 2011.
3. J. V. Aart, C. Bartneck, J. Hu, M. Rauterberg and B. Salem; How to behave as Alice in wonderland–about boredom and curiosity, Entertainment Computing, 1, pp.125-137, 2010.
4. M. P. Arnone, R. V. Small, S. A. Chauncey and H. P. McKenna; Curiosity, interest and engagement in technology-pervasive learning environments: a new

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**Table 1:** Result of multilevel analysis

| Model-1 | Model-2 |
|---------|---------|
| response | predictor | estimate | SE | response | predictor | estimate | SE |
| Level-1  | Joy$_{ij}$  | Unintelligibility | $\gamma_{ij}$ | 1.091 | .090 *** | Vagueness$_{ij}$  | Unintelligibility | $\gamma_{ij}$ | .699 | .045 *** |
| Level-2  | $\beta_{ij}$  | Diversive | $\gamma_{01}$ | 2.16 | .095 * | $\beta_{ij}$  | Diversive | $\gamma_{01}$ | .207 | .066 |
|         |          | Specific | $\gamma_{02}$ | -1.24 | .082 |
|         |          | Unintelligibility | $\gamma_{03}$ | -3.21 | .168 |
|         |          | (personal average) | $\gamma_{04}$ | 3.452 | .065 *** |
|         |          | $E_{0i}$ | .240 | .099 * |
|         | $\beta_{ij}$  | Diversive | $\gamma_{11}$ | .087 | .031 ** |
|         |          | Specific | $\gamma_{12}$ | .026 | .044 |
|         |          | Unintelligibility | $\gamma_{13}$ | -2.11 | .027 *** |
|         |          | (personal average) | $\gamma_{14}$ | .090 | .010 |

| Model fit | Model fit |
|-----------|-----------|
| AIC       | 4578.371  |
| BIC       | 4657.034  |
| AIC       | 3991.234  |
| BIC       | 4069.897  |

*Note.* Independent variables of level-1 were centered by group-mean centering; Independent variables of level-2 were centered by grand-mean centering.

* $p < .05$; ** $p < .01$; *** $p < .001$
research agenda, Educational Technology Research and Development, 59(2), pp.181-198, 2011.
5. J. Schmidhuber; Developmental robotics, optimal artificial curiosity, creativity, music, and the fine arts, Connection Science, 18(2), pp.173-187, 2006.
6. N. Shimo, S. Pang, K. Horio, N. Kasabov, H. Tamukoh, T. Koga, S. Sonoh, H. Isogai and T. Yamakawa; Effective and Adaptive Learning Based on Diversive/Specific Curiosity. In; A. Hanazawa, T. Miki and K. Horio (Eds.), Brain-Inspired Information Technology, Springer Berlin Heidelberg, pp.171-175, 2010.
7. D. E. Berlyne; Conflict, arousal and curiosity, McGraw-Hill Series in Psychology, New York, 1960.
8. P. J. Silvia; Exploring the psychology of interest, Oxford University Press, 2006.
9. T. Kashdan; Curious?: Discover the Missing Ingredient to a Fulfilling Life, William Morrow, 2009.
10. J. A. Litman, C.D. Spielberger; Measuring epistemic curiosity and its diversive and specific components, Journal of Personality Assessment, 80(1), pp.75-86, 2003.
11. M. N. Shiota, J. W. Kalat; Emotion (2nd Eds.), Cengage Learning, 2011.
12. P. J. Silvia; Appraisal components and emotion traits: Examining the appraisal basis of trait curiosity, Cognition and Emotion, 22(1), pp.94-113, 2008.
13. P. J. Silvia, R. A. Henson and J. L. Templin; Are the sources of interest the same for everyone? Using multilevel mixture models to explore individual differences in appraisal structures, Cognition and Emotion, 23(7), pp.1389-1406, 2009.
14. P. Kuppens, I. Van Mechelen, D. J. Smits, P. De Boeck, and E. Ceulemans; Individual differences in patterns of appraisal and anger experience, Cognition and Emotion, 21(4), pp.689-713, 2007.
15. H. M. Khalid; Embracing diversity in user needs for affective design, Applied Ergonomics, 37(4), pp.409-418, 2006.
16. K. Nishikawa and T. Amemiya; Development of an Epistemic Curiosity Scale: Diverse curiosity and specific curiosity, Japanese Journal of Educational Psychology, 63(4), pp.412-425, 2015. (in Japanese)
17. P. J. Silvia; Confusion and interest: The role of knowledge emotions in aesthetic experience, Psychology of Aesthetics, Creativity, and the Arts, 4(2), pp.75-80, 2010.
18. B. Reeves, and C. Nass; The media equation: How people treat computers, television, new media like real people and places, The Center for the Study of Language and Information Publications, 1998.

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