Reproducibility of unconscious thought effects and experimental tasks and materials optimization

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Reproducibility of unconscious thought effects and experimental tasks and materials optimization

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Introduction

Research Background

Unconscious Thought Theory

People always ignore their major work and move to other things, when they have headaches. After a break, a better decision for their major work is possibly made, compared with the situation when a conscious choice is contemplated. This mentioned phenomenon can be explained by *Unconscious Thought Theory* (UTT) proposed by Dijksterhuis (2004). According to this theory, it is indicated that in complex situations, better decisions are made from unconscious thought process. The UTT consists of six principles related to unconscious and conscious thought. The details are shown as follows.

the unconscious-thought principle.

Two modes of thinking conscious and unconscious thought are emphasized in this principle (Dijksterhuis, 2004). Different characteristics are expressed in these two modes. So that, these modes can be applied to several situations. *Conscious thought* (CT) refers to the cognitive and/or affective process realized by people consciously when attending a task. Oppositely, *Unconscious thought* (UT) refers to the mentioned processes realized unconsciously. To understand the theory of UTT, distinguishing the unconscious and conscious thought is an important target. Generally, conscious thought means thinking with attention, and thinking without attention (or diverting

attention elsewhere) is called unconscious thought. It should be paid attention that conscious thought does not include only the conscious processes. It can be compared with a speech that can be considered one kind of consciousness. Unfortunately, various unconscious processes (such as those responsible for choosing words or syntax) must be active to speak. Likewise, conscious thought cannot generate without unconscious processes being active at the same time (Dijksterhuis & Nordgren, 2006).

the capacity principle.

Conscious thought is constrained by the low capacity of consciousness. Oppositely, this constraint does not exist in unconscious thought because the unconscious shows a high capacity. Hence, conscious thought should only consider a subset of the information. It was found that 10 to 60 B/s of the process rate can be achieved in consciousness. However, for the entire human system, about 11,200,000 B/s of the process rate is reported (Bargh, 1994; Wilson, 2002). Conscious processing capacity is extremely small comparing with the processing capacity of entire human system. However, unconscious thought does not limit by processing capacity and larger capacity is observed in the case of unconscious thought. Thus, during the process of information processing, conscious thought use only a small fraction of the information effectively. Unconscious thought can focus on a broader range of content and evaluate the target thoroughly and deeply (Dijksterhuis & Nordgren, 2006).

the bottom-up-versus-top-down principle.

It is hard to avoid "jumping to conclusions" when conscious thinking is made because conscious thought processes are affected by the expectations and preexisting schemas. However, it may feel as if one is processing information to make a decision when what one unknowingly is doing is processing information to confirm an expectancy (Dijksterhuis & Nordgren., 2006). The reason is considered that unconscious thought can integrate complex information and make a relatively objective decision based on the overall situation. Generally, consciousness and unconscious works are considered as the top-down and bottom-up processes (Bos & Dijksterhuis, 2011), respectively.

the weighting principle.

Dijksterhuis and Olden (2006) posited that unconscious thought shows a better effect than conscious thought when an important attribute for objects is selected considering the weighting. The reason can be explained that people always pay some attention to unnecessary information when a comprehensive decision is made. This tendency destroys the natural weights of attributes, and the quality of decisions will be strongly affected. Conscious thought frequently overestimates the importance of certain attributes. Oppositely, unconscious thought can grasp the natural weight of attributes for objects accurately.

the rule principle.

Flaherty (1999) attempts to explain the difference between the conscious and unconscious based on uses rules of the association. Flaherty (1999) considers the conscious and unconscious are two different ways of dealing with rules. The conscious is the process for the application of rules. The relative problems can be solved if the rule is mastered. Extremely high accuracy is confirmed in this process. Additionally, the unconscious is good at discovering the law behind the phenomena. The unconscious can also extract consciously and be applied to other fields. The rules generate consciously during the process of unconscious thought. Research by Betsch, Plessner, Schwieren, and Gutig (2001) demonstrates that unconscious thought can estimates the result roughly. However, real arithmetic cannot be achieved from the process of unconscious thought. That is, the unconscious can deal with the number roughly without the arithmetic. In summary, conscious thought can make an accurate calculation based on rules and unconscious thought can be only used for estimation.

the convergence-versus-divergence principle.

According to the convergence-versus-divergence principle proposed by Dijksterhuis and Nordgren (2006), conscious thought is convergent when only the direct information is related to the goal or task. For unconscious thought, the process is divergent when bringing the information irrelevant to the goal or task. From this way, long periods of unconscious thought precipitate ingenuity where conscious thought would stagnate. Moreover, the convergence-versus-divergence principle is

more relevant for creativity than for choices or decisions.

Generally, the UTT breaks the concept based on "hard thinking produces good results". In the situation for making a decision, solving the problems, improving creativity, and impression formation, the UTT plays an important role. Same to other dual processing models (Levine, Halberstadt, & Goldstone, 1996), this theory pointed out that two main access channels exist on forming impressions. One channel requires more volitional effort and the other requires relatively slightly volitional effort. However, compared with these models, the UTT has two main characteristics. Firstly, it is believed that conscious thought (the channel that requires more willful effort) shows a better effect when making a simple decision, and it is better to use schemas and form stereotypes. Additionally, unconscious thought (the channel that does not require much willful effort) can solve complex problems better and makes less use of schemas. Secondly, unconscious thought does not work according to just the associative model. Conscious thought is not just a rule-based system either. Therefore, conscious thought is suitable for solving problems with simple or clear rules, and unconscious thought can be adapted for solving complex decision-making problems (Dijksterhuis & Nordgren, 2006).

Classic Experimental Paradigm

According to Dijksterhuis et al. (2004), the participants are divided into three conditions randomly: the conditions contained immediate decision-making condition,

conscious thought condition, and unconscious thought condition. Four options (apartments) named as No. 1 to 4 were considered experimental materials. Each apartment contained 12 attributes. Apartment 2 was the attractive (8 positive and 4 negative attributes) and the unattractive is given to apartment 4 (4 positive attributes and 8 negative attributes). Besides, apartments 1 and 3 were more neutral (6 positive attributes and 6 negative attributes), with a total of 48 attributes randomly presented to the participants. After the information was presented, in the case of the condition for the immediate decision, the evaluation of the four apartments on a 10-point scale was made immediately. In the case of the condition for conscious thought, the scoring started after 3 minutes of careful consideration. In the case of unconscious thought condition, the scoring is made after completing a 3-minute 2-back task. The results indicated that unconscious thought condition was better at identifying the attractive and the unattractive apartments. The immediate decision condition and conscious thought showed a bad performance, and no difference was observed between these two conditions. The results suggested that unconscious thought shows better performance than conscious thought in solving complex problems. This phenomenon is defined as unconscious thought Effect (UTE). Subsequently, this experiment is replicated and validated by other researchers (Strick, Dijksterhuis, & Baaren., 2010; Nordgren, Bos, & Dijksterhuis., 2011; Zhong et al., 2008), and this experimental method was widely used and recognized in unconscious thought field. It was called the classic experimental paradigm of unconscious thought.

Related Research

Numerous studies have verified the existence of the UTE. Payne et al. (2008) pointed out that compared with conscious thought, unconscious thought shows a better result. Zhong et al. (2008) proposed that unconscious thought helped solve a creative problem. Moreover, it was reported that unconscious thought can solve the problems fairly and the decision based on unconscious thought skewed towards the theory based on utilitarianism (Ham, van den Bos, & Van Doorn., 2009). González and Phillips (2010) indicated that in the situation for prediction of soccer matches, unconscious thought showed higher accuracy. Besides, the judgment of unconscious thought did not depend on the distinction between directly and indirectly obtained information, and always showed a better performance than the judgment of conscious thought (Ham & van den Bos., 2010). Messner, Wänke, and Weibel (2011) proposed that unconscious thought showed a positive effect on personnel selection. Handley and Runnion (2011) found that unconscious thought expressed a better effect on persuading others. The meta-analysis study by Strick et al. (2011) showed that the variable affected UTE contained the difficulty of decision-making tasks, stereotyped thinking, type of goal, information presentation methods, and the authenticity of the task situation. Yang (2012) proposed that the thinking time and difficulty of the distractor task also affected unconscious thought effect. Mealor and Dienes (2012) suggest that unconscious thought was in favor of discovering the rules. Creswell et al. (2013) found that in unconscious thought condition, the right dorsolateral prefrontal cortex and left middle visual cortex of the brain, maintain activated during the process

of distractor tasks by using fMRI. Furthermore, it was proposed that unconscious thought can integrate the segmental information based on the characteristics for each segment (Li et al., 2014). In a neuroimaging study, conscious thought was fixed in specific areas in the brain (Kegeyama, 2019).

However, several challenging works related to UTE have been done. Withrow and Thorsteinson (2009) found that participants in unconscious thought condition did not perform significantly better than did participants in conscious thought condition. Moreover, Lassiter et al. (2009) believed unconscious thought was one kind of conscious thought based on linearly-judgment, unconscious thought did not exist. Nieuwenstein et al. (2015) pointed out that the UTE effect is the result of errors in a small sample. This question was confirmed after experimenting used a large number of samples and the nonexistence of unconscious thought was confirmed.

Based on the above studies, the existence of the UTE is still controversial. The existence of UTE is unstable, it may depend on moderating the variables in an experiment and the errors generated from the experiment. Therefore, the conditions for the existence of UTE in previous studies should be researched, and the studies on moderating variables are insufficient.

Hypotheses and Predictions

According to the hypothesis proposed by Dijksterhuis and Nordgren (2006), in the process of processing complex information, unconscious thought expresses a better decision compared with conscious thought, and the existence of UTE is exactly. The reason can be considered that unconscious thought has a larger cognitive capacity compared with conscious thought, and it is suitable for the situation for integrating large numbers of information and making decisions in complex situations. Moreover, when weighing the importance of attributes, unconscious thought is better at comparing the several forming global impressions in different alternatives (Huizenga, Wetzels, van Ravenzwaaij, & Wagenmakers., 2012; Dijksterhuis, & Nordgren., 2006; Mamede & Schmidt., 2010). Therefore, it can be predicted that in this study, in the situation for making a complex decision, the performance of unconscious thought (UT) condition will be better than that of conscious thought (CT) condition when making a decision. The UTE will be generated with unconscious thought.

Purpose and Significance of the Study

This study examines the reproducibility of the UTE by replicating and improving the classical experiment by Dijksterhuis (2004). On this basis, it delves into the effects of experimental factors on unconscious thought. Study 1: Exploring the reproducibility of the UTE by optimizing the experimental material (using job information as experimental materials). Study 2: Exploring the effect of experimental distractor task on the UTE by changing the difficulty of distractor task in the UT condition.

By copying the classical experimental paradigm and conducting the experiment more rigorously, the UTE will be verified again. This study can provide valid data for the existence of UTT furtherly. Moreover, by exploring the factors which can affect unconscious thought and improve the experiment accordingly. This study can provide a new perspective on decision-making.

Study 1

Questions and Hypotheses

In the previous study, apartments, cars, telephones, etc. were used as experimental materials. However, Bargh et al. (2011) showed the superiority of unconsciously made decisions in more ecologically valid "real-life" judgmental situations for which natural selection has likely equipped us with unconsciously operating expertise, compared to the artificial situations studied by the decision theorists (which often involve numerical computations). The ecological (more relevant to life) of the task showed a positive sensitivity on unconscious thought in the processing of complex situations. Therefore, in this study, the experimental materials close to life were selected to investigate the existence of UT by replicating classic experiments. The existence of UTE will be predicted and the performance in UT condition will show a better effect compared with the CT condition in complex decision-making tasks.

Preliminary Investigation

To select the target task material for this experiment, a preliminary survey related to evaluation work attributes was conducted online.

Participants

A total of 60 participants (College and graduate students) were recruited through the China website (Questionnaire Star).

Materials

The job information attributes were collated through previous studies (Gokuladas., 2010; Zhao., 2016; Zhou., 2013). 20 initial job information attributes were selected, and then 60 participants were asked to take a survey on the importance rating scale of 0-10 through an online questionnaire.

Results

After excluding 8 extreme values (4 extremely important and 4 extremely unimportant), 12 attributes were finally selected to constitute the target task material for this experiment. The attributes were shown as follows: location of work, being able to use your talents, promotion space, interpersonal harmony, freedom, personal professional growth, the intensity of work, working environment, work can be combined with the interest, company culture, company size, training.

Methods

Participants

An *a priori* power analysis with the software G*Power (Faul et al., 2007) was conducted to determine the required sample size for the planned contrast analysis central to our hypotheses that would allow to reveal medium-size effects with an α = 5% and 1-β = 80%. This analysis suggested a required sample size of at least N = 128.

Online recruitment was conducted through Kyushu University's internal website, social software such as WeChat. A total of 149 Chinese college and graduate students were recruited. The data that did not conform to the requirements were excluded (in the post-test survey, 7 people exceeded the standard value in the questionnaire on the importance of job attributes, and 4 people chose to read the information while making decisions with 100% probability in the survey on participants' decision-making time), and the final valid data was 138 (M = 23.26, SD = 2.74). There were 47 participants in the UT condition (20 males, 27 females), 46 participants in the CT condition (16 males, 30 females), and 45 participants in the immediate decision-making condition (15 males, 30 females). All participants had the normal or corrected vision, and all were right-handed.

Materials

Target task materials: This experiment took the job selection task which was

closer to the college student's life as the experimental materials. According to the classical experimental setting (Dijksterhuis, 2004), the 12 attributes obtained from the preliminary survey were combined into 4 job options according to different proportions of positivity and negativity: 1 the attractive job, 1 the unattractive job, and 2 middle jobs. Among them, the attractive job has 8 positive attributes and 4 negative attributes, the unattractive job has 4 positive attributes and 8 negative attributes, and the middle job has 6 positive and 6 negative attributes each.

Distractor task (2-back task) materials: For participants to judge whether the number was the same as two before, it was needed to prepare the numbers: 0-9.

Procedure

The program employed in this study used the jsPsych and the psychophysics plugin (De Leeuw, J. R., 2015; Kuroki, D., 2021). This experiment divided the participants into three conditions (the CT condition, the UT condition, and immediate decision condition). Before the experiment began, the participants were presented with instructions and practice questions to guide them to familiarize themselves with the experimental procedures and tasks.

When the experiment started, firstly, the information presentation stage was made. 4 work options and 48 attribute information were contained. Each job option was presented for 12000 ms, and the next information was presented after every 2000 ms interval. Then, it was a move to the thinking stage. After all the information was

presented, the immediate decision-making condition did not have time to think and went to the evaluation stage directly. Besides, the CT condition had 3 minutes to think about the information of four jobs carefully. The instructions and countdown were displayed on the screen. The UT condition was also given 3 minutes to complete the 2-back distractor task to prevent them from consciously thinking about the information presented before. Next, the selection and rating stage was carried out. Participants were required to choose one of the options that they thought was the best. Simultaneously, their impression of four jobs was scored on a scale of 0-10. Finally, it went to the post-test survey stage: one is a questionnaire about when the participants make decisions, which was designed to control the time at which participants made their decisions. (1. When did you make your decision? A. When reading while making decisions. B. After reading all information. 2. What is the probability that you made decisions while reading? A.0%; B.25%; C.50%; D.100%). Another questionnaire was related to the importance rating of job attributes (same as the preliminary survey's questionnaire), to control participants' subjective preferences for job attributes. Figure 1 shows the procedure of the experiment.

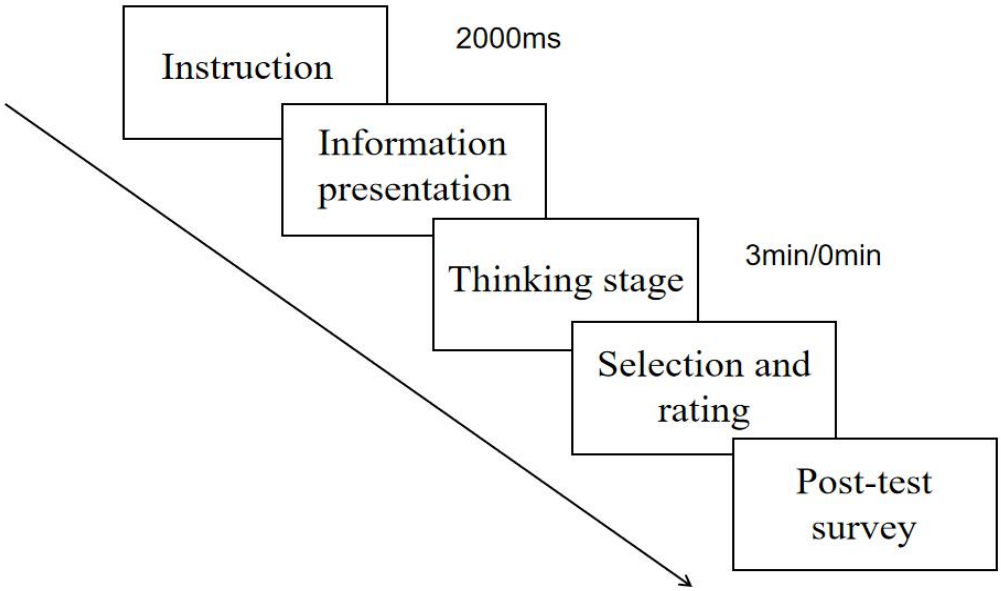

Figure 1. the procedure of the experiment.

Results and Discussion

Data Processing

In the present study, the data non-conformed to the criteria were excluded, including 7 participants whose probability for making decisions while reading information was 100% in the post-test survey, and 4 participants whose score of job attribute importance exceeded the level of the sample in the preliminary survey (In other words, the score exceeds the sample mean $\pm$ 2SD). Finally, a total of 138 valid data were obtained, including 46 people in the CT condition, 47 people in the UT condition, and 45 people in the immediate decision condition.

Regarding data analysis, two dimensions were be used to show the performance of decision-making. One is the percentage of participants who chose the best job was calculated, and this selection rate represents the accuracy rate. Another is the difference between the most attractive job and the most unattractive job rating score was calculated to consider the ability for each participant to judge the best from the worst job. The higher the difference of scores, the stronger the distinguishing ability and the better the quality of decision-making.

Results

accuracy in choosing the attractive job.

The accuracy of participants in choosing the attractive job under each of the three conditions is shown in Figure 2. The percentages of participants choosing the attractive job were compared. As expected, participants in the UT condition most often made the right choice (68.1%). Participants in the CT condition and the immediate decision-making condition did not perform as well (43.5% and 48.9% made correct choices, respectively). This showed the trend of unconscious thought effect: in a complex decision-making situation, participants in the UT condition performed better than those in the CT condition. A chi-square test was carried out on the three thinking conditions in terms of accuracy. The results were as follows: χ^2（2, 138）= 6.26, p = 0.044, Cramer's V = 0.213; this indicates that in complex situations, there was a significant difference in accuracy among the three thinking modes. Then a

two-by-two comparison was made separately. The accuracy of the UT condition was significantly higher than the CT condition, χ^2 (1, 93) = 5.71, p = 0.017, φ = 0.248, and the UT condition performed better than the immediate decision-making condition, although the difference was not significant, χ^2 (1, 92) = 3.49, p = 0.062, φ = 0.195. Moreover, there was no significant difference between the immediate decision-making condition and the CT condition, χ^2 (1, 91) = 0.268, p = 0.605, φ = 0.0543.

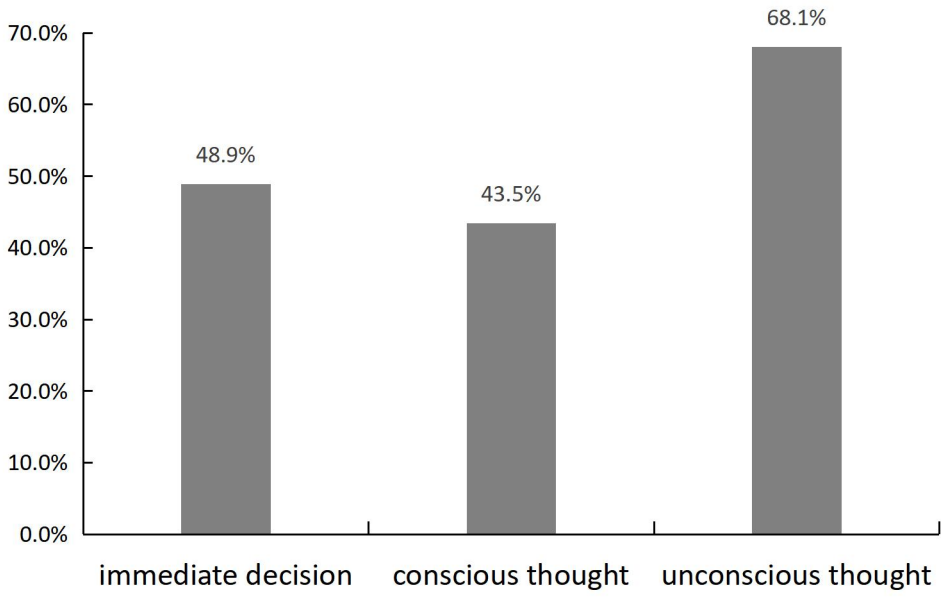

Figure 2. Accuracy in choosing the attractive job in different conditions.

differential attitude scores under different thinking modes.

It was first confirmed that overall, the attractive job was judged as more attractive than the unattractive job. Indeed, the overall attitude toward the attractive job was higher (M = 6.14) than the attitude toward the unattractive job (M = 4.36). The measurement of interest is how well participants differentiate between the attractive job and the unattractive job. Hence, difference scores were calculated by subtracting the attitude toward the unattractive job from the attitude toward the attractive job. The result was that the UT condition (M = 2.40, SD = 1.94) performed better than the CT condition (M = 1.63, SD = 1.88) , and the immediate decision condition (M = 0.91, SD = 2.13) performed poorly.

The result of a one-way analysis of variance (ANOVA) showed that the differential attitude scores were significantly different in three thinking modes, $F(2, 135) = 5.76$, $p < 0.01$, $\eta^2 = 0.079$. This suggests that there was a significant difference between the three thinking conditions in participants' ability to distinguish between the attractive and the unattractive job (**Figure 3**).

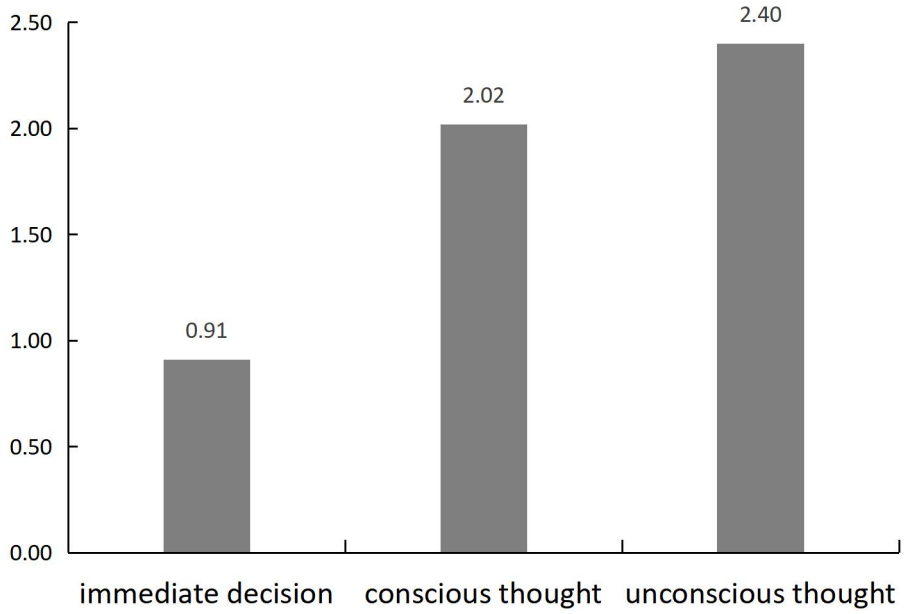

Figure 3.The mean of the differential attitude scores under different thinking conditions.

The Paired T-Test comparisons of differential attitude scores under three thinking modes showed that the differential attitude scores under the UT condition were significantly higher than those under the immediate decision-making condition, t (44) = 4.13, $p < 0.001$, $d = 0.616$. The differential attitude scores under the CT condition were significantly higher than those under the immediate decision-making condition, t (44) = 2.04, $p = 0.047$, $d = 0.304$. In addition, between the UT condition and the CT condition, there were not any significant results, t (45) = 0.783, $p = 0.438$, $d = 0.115$.

Discussion

Study 1 verified the reproducibility of UTE by optimizing experimental materials. The results showed that the differences exist in the results of the three thinking conditions when a complex decision was made. For one thing, is the accuracy of the attractive job choice, its accuracy of the UT condition was higher than that for the other two conditions, and there was a significant difference between the UT condition and CT condition. These are consistent with previous work indicating that an apparent advantage of decisions made after distraction over those made after deliberation, and the relative inferiority of CT was the consequence of the low processing capacity of consciousness (Dijksterhuis et al., 2006). Moreover, it can also be explained by the neural reactivation hypothesis. It was found that during the encoding of complex decision information, the same regions activated (right dorsolateral prefrontal cortex and left intermediate visual cortex) continued to be activated only in the UT period, which improved the performance of decision-making (Creswell, Bursley, & Satpute., 2013).

For another is differential attitude scores under different thinking modes, and the same results were shown. The UT had the best ability to distinguish between the attractive job and the unattractive job in three thinking conditions. However, unexpectedly, although the immediate decision-making condition performed better than the CT condition in the accuracy of selection, it was significantly lower than the CT condition in differential attitude scores. Examining the results in the immediate decision-making condition allowed us to properly evaluate the effect of the

experimental manipulation. When instructed to "rate the four jobs" participants who subsequently made their decision immediately were able to differentiate the attractive job from the others: Their accuracy of selection was 48.9%. This implies that the alternatives had been properly compared during information acquisition. It can be surmised that in the memorization condition, participants who had to provide their attitudes immediately had poor ability to compare the alternatives during information acquisition and failed to properly differentiate the best option from the others. By contrast, the UT and CT condition which had 3 minutes can carry out the comparison between alternatives during the post-acquisition period based on their memory for the attributes and thus adjusted their first impressions. In this case, because differentiation was very poor after information acquisition, this conscious comparison process made it possible for participants to compensate for the lack of on-line comparison and thus to enhance the quality of their decisions (Waroquier, Marchiori, & Cleeremans., 2010).

To summarize, the differences in the accuracy for choosing the attractive Job and attitude scores showed that the participants' decision-making performance was significantly higher in the UT conditions than in the CT condition. This finding verified the existence of the UTE. These results are also consistent with those of previous studies (Dijksterhuis, 2004; Dijksterhuis et al., 2006). The results suggest that UT had an advantage in making multi-attribute choices following a complex situation.

Study 2

Questions and Hypotheses

It was found that the level of difficulty for the distractor task affects the UTE, and previous work showed that the participants who were distracted with the easier tasks (listening to music and word search puzzles) outperformed participants distracted with more difficult tasks (McMahon, Sparrow, Chatman, & Riddle, 2011). According to this theory, when the difficulty of the distractor task in the UT condition was changed to an easier 0-back task, it is possible to replicate the UTE. Thus, Study 2 explored the effects of distractor tasks on UTE by optimizing the distractor task.

According to the hypothesis of McMahon et al. (2011), distraction with the least amount of cognitive demands are the optimal choice for the UTE. The reason is that simple tasks occupy less attentional resources and will not obstruct unconscious processing. Therefore, it can be predicted that the performance of participants in UT 0-back condition will be higher than that in UT 2-back and CT conditions.

Methods

Participants

An *a priori* power analysis with the software G*Power (Faul et al., 2007) was conducted to determine the required sample size for the planned contrast analysis central to our hypotheses that would allow to reveal medium-size effects with an α = 5% and 1-β = 80%. This analysis suggested a required sample size of at least N = 128.

Participants were recruited online through the Chinese website "Love Experiment". This time, to unify the participants, people who had experience in job hunting were being recruited. A total of 135 Chinese college and graduate students participated in the current study. The data that did not confirm the requirements were excluded (in the post-test survey, 13 people exceeded the standard value in the questionnaire on the importance of job attributes, and 3 people chose to read the information while making decisions with 100% probability in the survey on participants' decision-making time), and the final valid data was 129 (M = 22.26, SD = 2.36). There were 41 participants in the CT condition (18males, 23females), 45 participants in the UT 2-back condition (14 males, 31 females), and 43 participants in the UT 0-back condition (18 males, 25 females). All participants had a normal or corrected vision, and all were right-handed.

Materials

Target task materials: Same as Study 1.

Distractor task materials: the 2-back task was the same as Study 1. Moreover, the 0-back task was needed to prepare the number 0-9 to make participants for judging the current number (the number was random).

Procedure

The program employed in this study used the jsPsych and the psychophysics plugin (De Leeuw., 2015; Kuroki., 2021). This experiment divided the participants into three conditions (the CT condition, the UT 0-back condition, and the UT 2-back condition). As in the procedure of Study 1, firstly, the information presentation stage was made. 4 work options and 48 attribute information were contained. Each job option was presented for 12000 ms, and the next information is presented after every 2000 ms interval. Then, it was moved to the thinking stage. The CT condition had 3 minutes to think about the information of four jobs carefully. The instructions and countdown were displayed on the screen. The UT 0-back and 2-back conditions were also given 3 minutes to complete the distractor task to prevent them from consciously thinking about the information presented before. Next, the selection and rating stage was carried out. Participants were required to choose one of the options that they thought was the best. Simultaneously, their impression of the four jobs was scored on a scale of 0-10. Finally, it went to the post-test survey stage: one is a questionnaire

about when the participants make decisions, which was designed to control the time at which participants made their decisions. (1. When did you make your decision? A. When reading while making decisions. B. After reading all information. 2. What is the probability that you made decisions while reading? A.0%; B.25%; C.50%; D.100%). Another questionnaire was related to the importance rating of job attributes （same as the preliminary survey’s questionnaire） to control participants' subjective preferences for job attributes.

Results and Discussion

Data processing

In the present study, the data that did not meet the criteria were excluded, including 3 participants whose probability of making decisions while reading information was 100% in the post-test survey, and 13 participants whose score of job attribute importance exceeded the level of the sample in the preliminary survey (In other words, the score exceeds the sample mean $\pm 2SD$). Finally, a total of 129 valid data were obtained, including 41 people in the CT condition, 45 people in the UT 2-back condition, and 43 people in the UT 0-back condition.

Results

accuracy in choosing the attractive job.

The accuracy of participants in choosing the attractive job under each of the three conditions is shown in Figure 4. The accuracy of the UT 2-back condition was 53.3%; the CT showed the lowest level of accuracy, at 46.3%. This confirmed the trend of the UTE. Accidentally, the accuracy of the UT 0-back condition (51.2%) was lower than that of the UT 2-back condition. A chi-square test was carried out on the three thinking conditions in terms of accuracy and the result was χ^2（2, 129）= 0.435, p = 0.805, V = 0.0581, no significant differences were observed in participants' accuracy in choosing the best job among the three thinking conditions. Then a two-by-two comparison was made separately. The accuracy of the UT 2-back condition was higher than the CT condition, but there were no significant differences between conditions, χ^2 (1, 86) = 0.42, p = 0.517, φ = 0.0698. The UT 0-back condition performed better effect than the CT condition, but there were no significant differences between conditions, χ^2 (1, 84) = 0.195, p = 0.659, φ = 0.0482. Moreover, the UT 2-back condition performed better effect than the UT 0-back condition, but there were also no significant differences between two conditions, χ^2 (1, 88) = 0.0415, p = 0.839, φ = 0.0217.

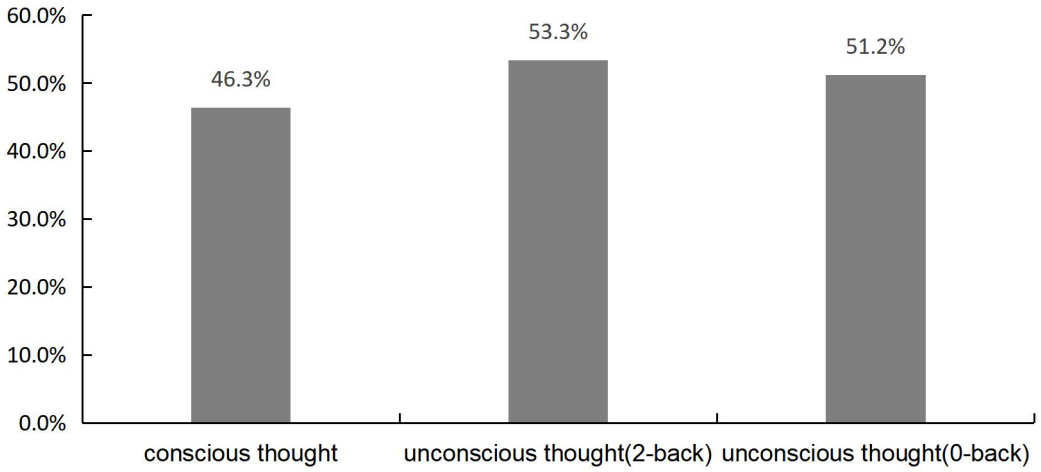

Figure 4. Accuracy in choosing the best job in different conditions.

differential attitude scores under different thinking modes.

According to the results, the overall attitude toward the attractive job was higher (M = 6.13) than the attitude toward the unattractive job (M = 4.7). The measurement of interest was based on how the participants distinguish the difference between the attractive job and the unattractive job. Hence, difference scores were calculated by subtracting the attitude toward the unattractive job from the attitude toward the attractive job. The result was that the UT 2-back condition (M = 1.96, SD = 2.95) performed better effect than the UT 0-back condition (M = 1.30, SD = 2.97). This shows that UT 2-back fared relatively well. The UT condition (0-back) performed poorly effect (M = 0.95, SD = 2.12) indicating lack of clarity about preference for attractive jobs.

The result of a one-way analysis for variance (ANOVA) showed that the differential attitude scores were not significantly different in the three thinking modes, ($F(2, 126) = 1.52$, $p = 0.223$, $\eta^2 = 0.024$). This suggests that there were no significant differences between the three thinking conditions in participants' ability to distinguish between the attractive and the unattractive job (**Figure 5**).

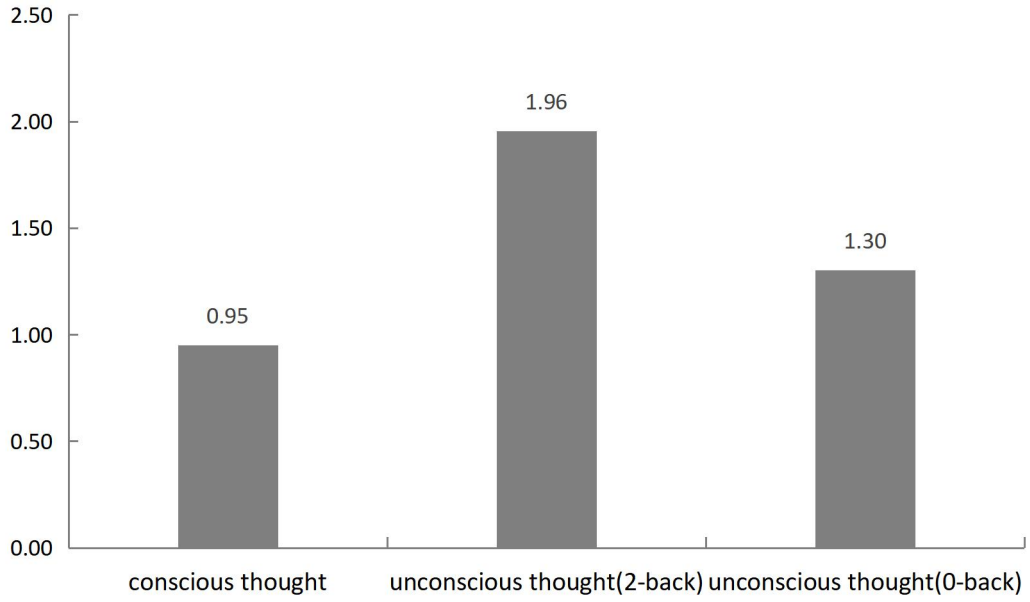

Figure 5. The mean of the differential attitude scores under different thinking conditions.

The Paired T-Test comparisons of differential attitude scores under three thinking modes showed that the differential attitude scores under the UT 2-back condition were higher than those under the CT condition, but there were no differences between conditions, t (40) = 1.43, p = 0.160, d = 0.224. The differential attitude scores under the UT 0-back condition were higher than those under the CT

condition and showed no differences between conditions, t (40) = 0.642, p = 0.524, d = 0.100. In addition, it also did not yield any significant results between the UT 2-back condition and the 0-back condition , t (42) = 1.02, p = 0.314, d = 0.115.

Discussion

Two dimensions of accuracy in choosing the attractive Job and attitude scores showed that the performances of UT condition were higher than that of the conscious thinking state. However, results failed to find statistically significant differences in performance between participants in the UT condition and those in the CT condition. Since scientific conclusions decisions should not be based only on whether a p-value passes a specific threshold (Wasserstein & Lazar, 2016; Cumming, 2008), and effect sizes are more useful than p-value in helping researchers to correctly understand statistical results (Coulson, Healey, Fidler, & Cumming, 2010), the current study added effect size to examine results. According to the criteria of Cohen's d and phi correlation coefficient (Cohen, 1998; Akoglu, 2018), in comparisons among conditions, it can be seen that almost all obtained effect sizes were small, this means the differences of results were unimportant and limited to practical applications. In conclusion, although the unconscious had a moderate advantage in scores, there were no significant differences among conditions and the effect sizes were small. Therefore, It can be considered that the results of Study 2 did not have strong practical significance and the results were not completely consistent with Dijksterhuis (2004).

It can be inferred that the UTE is unstable. Previous studies had also pointed out this and suggested that the true effect size for unconscious thought was much smaller than assumed so far or this experimental approach was not suitable to demonstrate unconscious thought effect (Acker, 2008).

Contrary to predictions, the results showed that the UT 0-back condition did not perform better effect than the UT 2-back condition (although there were no significant differences), however, these disproved the hypothesis that distraction with the least amount of cognitive demands was the optimal choice for the UTE (McMahon, Sparrow, Chatman, & Riddle, 2011). The following possibilities are inferred: the first possibility is the existence of a threshold in the adjustment process of unconscious thinking. Even though the UTE was moderated by the cognitive demands of the distraction task (Abadie, Waroquier, & Terrier., 2013), it did not mean that the most distractor task was simple, the effect was the best. Furthermore, a moderate level was requested in the situation of distraction. Secondly, unconscious thought showed a higher capacity. From this viewpoint, the conscious processing of the decision task was requested to be prevented when performing a highly demanding distraction task. The considerable processing capacity of the unconscious should also be allowed to operate (Dijksterhuis, & Nordgren, 2006). Therefore, in the current study, compared with the demanding distraction task, a larger UTE is requested when the more-demanding distraction task was used.

General Discussion

The current study examined the reproducibility of the UTE. Study 1 examined whether (some) the evidence for the existence of a UTE can be found by optimizing the task materials (using the job information). The results showed that the performances of the UT condition were significantly higher than those for the CT condition. It means that the UTE (Dijksterhuis, 2004) was successfully reproduced. Based on Study 1, Study 2 explored the effect of the difficulty for the distractor task on UTE. The results showed that there were no significant differences between UT and CT conditions, even though the UT showed a higher score compared with the CT. Thus, UTE in Study 2 was not successfully reproduced. Furthermore, the results showed that there were no significant differences between the UT 0-back and the UT 2-back conditions. It was indicated that the difficulty of the distractor task did not affect UTE. Overall, these direct that the debate concerning the reproducibility of UTE is still ongoing.

explanations for the UTE.

The results suggest that UT offered some benefit and may reflect an intermediate process before a decision is reached. This can be explained by the six principles proposed by Dijksterhuis and Nordgren (2006) : such as, according to the capacity principle, during the process of information processing, conscious thought used only a small fraction of the information effectively. Unconscious thought focused on a broader range of content and evaluate the target thoroughly and deeply because it did

not limit by processing capacity; according to the bottom-up-versus-top-down principle, unconscious worked bottom-up processes, that can integrate complex information and make a relatively objective decision based on the overall situation. Therefore, when a complex situation was faced, unconscious thought was more conducive to obtaining high-quality decisions by selecting unconscious thought; according to the weighting principle when an important attribute for objects is selected considering the weighting, unconscious thought grasped the natural weight of attributes for objects accurately; according to the convergence-versus-divergence principle, conscious thought was convergent when only the direct information was related to the goal or task. For unconscious thought, the process was divergent when bringing the information irrelevant to the goal or task. Thus, unconscious thought showed a better effect than conscious thought. The second explanation is that providing a general impression formation goal was beneficial to the UTE. Unconscious thinking is an active process that is only evoked when a goal such as impression formation (Bos et al., 2008) was provided to participants to make a decision. In this study, setting a task goal such as having participants evaluate four jobs to form a general impression led to the better arousing of unconscious thought. Moreover, it can also be explained by the neural reactivation hypothesis which suggested that the same neural regions activated continued to be activated only in unconscious thought period (Creswell, Bursley, & Satpute., 2013).

explanation for the poor performance of the immediate decision condition.

Since the immediate decision condition can make decisions immediately after the information acquisition, this prevented on-line judgments. As a result, it failed to differentiate the best job from the others resulting in poorer performances properly. So that the performance of the immediate decision-making condition was worse than that for the UT and CT conditions (Bos et al., 2008).

By contrast, participants in the UT and CT conditions can improve their decisions by adjusting their first impression. Even though participants reported a first impression simply after 3 minutes, conscious thinking can deteriorate decisions that have already been made. In this case, the differentiation was very poor after information acquisition. Therefore, with respect to time, participants in unconscious thought and conscious thought conditions could carry out the comparison between alternatives during the post-acquisition period on the basis of their memory for the attributes. Subsequently, participants in unconscious thought and conscious thought conditions improved the quality of their decisions by compensating for the lack of on-line comparison (Waroquier, Marchiori, Klein, & Cleeremans., 2010).

the variables of the difficulty of the distractor task.

From the comparison between two distractor tasks in two conditions, the results showed that compared with the UT 2-back condition, the UT 0-back condition was not superior to the UT 2-back condition for complex problem-solving. These are

inconsistent with the previous research (McMahon, Sparrow, Chatman, & Riddle, 2011). It can be considered that not the easier the distractor task, the better the effect of UTE. A threshold of distractor difficulty existed probably in the UT. Previous work indicated that the accuracy of decision-making will be reduced in the situation of engaging the difficult distractor because the attention resources will be occupied overmuch (McMahon, Sparrow, Chatman, & Riddle., 2011). Thus, Even though the 0-back task was easier than the 2-back task, there was no significant difference between the 0-back and the 2-back tasks. The reason is possible that both of them did not have a higher levels cognitive load, and lots of working memory or attention resources were not requested. Further work can determine the type of distractor or the threshold of distractor difficulty benefitted to the UTE.

explanation for the significant difference in study 1 but not in study 2.

It should be paid attention that Study 1 reproduced the UTE successfully. However, the UTE in Study 2 was failed. It can be explained from the following three perspectives. One may be caused by individual differences. Since the operation procedures and prompts of the two experiments were the same, the influence of variables as experimental manipulation on the results was impossible. However, participants in the two experiments were different, so that, there is a possibility that it was caused by individual differences, such as education, gender, or understanding of the task. The second possibility was considered that knowledge related to tasks can

affect the UTE. Compared with Study 1, Study 2 selected the participants with job hunting experience to control the participants. It is speculated that when the task materials was experienced, the advantages of unconscious thought in complex decision making will be eliminated. Thirdly, the effect sizes of Study 2 were small, it can be considered that the false negatives occurred in Study 2. Due to the subtlety of the variables in psychological research, direct repetition did not produce the initial effect probably (Stroebe & Strack, 2014). False negatives caused by the lack of statistical power of the repeated study itself may also be a major reason for repeated failures (Maxwell, Lau, & Howard., 2015; Vankov, Bowers, & Munafò., 2014). The fourth explanation is "memory distortion". There was a possible reason that the information retrieval process can cause some distortion during thinking, and then impact decision performance (Hu, Yu, Chu, Zhao, Jude, & Jiang., 2018).

reflections on replicability studies.

By the way, the main problems of reproducibility studies were not only the false negatives in the replication experiments mentioned above but also the false positives in the initial experiments (such as suspicious research operations and publication biases, etc.). For this reason, many researchers proposed to select more open and transparent research standards (Carp, 2013). The openness and transparency should be maintained until the end of the study or the publication of the articles. Currently, pre-registration studies are commonly used in replicate studies (Chambers, Dienes, McIntosh, Rotshtein, & Willmes., 2015). Even though this study has not been

pre-registered, it is hoped that the pre-registration will be possible in the future to ensure the reliability of the replicability studies.

Limitations

This study tried to control the variables which affect the experiment (such as instructions and presentation time, etc.). And the classical paradigm of UTE was also replicated seriously. However, due to the limitation of the online method, it is suspected that experimental operation errors (such as the improper operation of participants, uncontrolled experimental environment, etc.), may affect the results and the effect size. In addition, the individual differences were exciting because the participants came from different schools or regions. Since the subjects were not completely controlled, it is possible that individual differences also affected the results of UTE. Moreover, it is hoped that the external factors which affect UTE, and the inner relationship that exists between the unconscious and the conscious will be explored deeply in the future.

Conclusion

This study replicated a classical paradigm of UTE (Dijksterhuis, 2004), validated the reproducibility of UTE, and examined its effect on reproducibility by optimizing the experimental materials and tasks. The UTE was successfully reproduced by using the optimized materials in Study 1. However, the results of Study 2 were inconclusive. No advantages were found in unconscious thinking and optimizing tasks. To summarize, it can be known that the advantages of the unconscious were confirmed, even though the stability of the UTE was weak. Therefore, overemphasizing the UTE is inappropriate. For the application, the UTE may be limited by the selection of samples and the experimental operation process. Hence, a careful operation is requested. Maybe this theory should not have been relied excessively upon. The variables and thresholds which affect the stability of the UTE will remain to be examined in the future.

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Appendix

Appendix A. Importance of Attributes Evaluation Questionnaire

评分规则说明:0分表示选择工作时完全不考虑该属性，从1分到10分表示重要：度逐步上升。请您按照选择工作时的实际情况对这些属性进行评分。

一、基本资料

为了便于统计分析，敬请您填写以下基本信息：（以下题目均为单选，请在所选答案的序号上画对号）

（1）您的性别：1.男 2.女

（2）您的年龄：1.20岁以下 2.21-25岁 3.26-30岁 4.30岁以上

（3）您是否有过工作经验：1.有 2.无

二、评分

工作所在地

不考虑○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9 ○10极其重要

职业晋升空间

不考虑○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9 ○10极其重要

工作和兴趣相结合

不考虑○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9 ○10极其重要

行业前景

不考虑○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9 ○10极其重要

工资和福利

不考虑○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9 ○10极其重要

工作和生活的平衡度

不考虑○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9 ○10极其重要

个人专业的成长性

不考虑○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9 ○10极其重要

公司文化/理念/价值观

不考虑○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9 ○10极其重要

公司的知名度

不考虑○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9 ○10极其重要

工作的安全性

不考虑○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9 ○10极其重要

社会影响力

不考虑○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9 ○10极其重要

人际关系和谐

不考虑○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9 ○10极其重要

工作强度

不考虑○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9 ○10极其重要

能发挥自己的才能

不考虑○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9 ○10极其重要

有可靠的社会保险体系

不考虑○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9 ○10极其重要

具有自由性/自主性

不考虑○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9 ○10极其重要

有出国的机会

不考虑○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9 ○10极其重要

工作环境/公共设施

不考虑○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9 ○10极其重要

研修/培训

不考虑○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9 ○10极其重要

公司的规模

不考虑○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9 ○10极其重要

Appendix B. Examples of Job Information Materials

工作A

人际关系和谐
工作环境优
企业文化优
公司规模大
工作自由度高
工作地点不便
晋升空间小
个人成长性低
发挥自己的才能空间小
培训制度完善
工作强度小
工作和兴趣结合度高