Can subliminal signal affect human's judgment and decision-making?

—— A helpful study for designing computerized decision support systems

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Abstract

Decision theory and research are genuinely interdisciplinary. For engineers, the interest in designing computerized decision support systems has considerably increased in recent years. The current decision support systems mainly focus on data acquisition and analysis. They are responsible for providing large amounts of data continuously and delivering adaptable models, which can enable people to use these results effectively and then make decisions more quickly and accurately. Then, is there any real-time decision support system in the future that can change human's judgment and decision-making? This paper will show you the answer. It presents the results of a study that subliminal vision signal may have direct influence on human's advanced cognitive process and finally change human's decision under ambiguity.

Keywords: Decision support system; Subliminal vision signal; Unperceived; Judgment; Decision making; Uncertainty; Ambiguity; Ellsberg paradox

I. INTRODUCTION

People,by human nature, are not optimal decision-makers. There are several factors that hinder the decision-making process, e.g. cognitive biases, accidents, cultural motivations and missing knowledge[1]. So, it is necessary to provide favorable technological support for managers to make decisions. And it has been generally acknowledged as a new field of Human-Machine Interaction with the most promising future in 21st century. At present, with the help of such conventional decision support systems, people can improve their working efficiency[2]. However, in such situations, the decision maker's final judgment is still based on his or her own inherent disposition. The function of additional decision support systems in the future will not limited to providing plenty of data to help decision. The ideal goal is to enhance understanding of human decision-making processes and then change human's inward decision if necessary. This is a challengeable task, and first of all, it needs engineering psychologists' hard work .

Decision making is an advanced cognitive process, which is the core component of human intellectual activity. It involves comparing, evaluating alternative solutions and finally making the optimal choice, this process will take a lot of cognitive resources[3]. Decision making can be divided into two categories: certainty and uncertainty. The former means that all options are pretty sure in the decision-making situation and people may judge or determine based on his individual subjective value; while the latter refers to uncertainty of objective value or probability of each option, even both is uncertain. Decision making under uncertainty can be divided into two kinds, one is ambiguity decision-making and the other is risk decision-making. In the fuzzy situation, people have no way to estimate the probability by experience or reasoning, so they usually have to make decisions in accordance with subjective probability. Psychologists have conducted many studies on ambiguity decision making, but there is no research on the effect of subliminal perception on it. Therefore, we investigated whether human's choice changed in the case of uncertainty if they accepted some unrealized information[4,5].

II. METHOD

A slightly changed paradigm of Ellsberg paradox was used in this paper. Participants were seated and received stimuli from the screen of a computer or the headphones，then they were asked to finish the two-alternative forced-choice task and to response by keyboard as quickly as possible. Their task was to choose an urn (A or B) to make a blind drawing of red ball.

A. *Participants*

The 34 participants recruited for this experiment are students and all of them have normal visual acuity (or corrected visual acuity) and normal hearing. The male and female participants were between 20 and 26 years old. The age and gender distribution of the participants is provided in Table 1.Participants were paid 10 RMB/person for their participation, and were asked to sign an informed consent form before commencing testing. The whole test session lasted about 20min.

Table1. Characterization of participant gender, age and number

Gender	Number	Average age(years)
male	16	22.94 ±1.81
female	18	21.83 ±1.47

B. *Stimuli*

There were two kinds of subthreshold stimuli, one was subliminal visual stimuli, presented through the computer's LED screen; and the other was subliminal auditory stimuli, presented through the headphones. In previous literature, researchers usually control the presentation time (shorter than 13ms) in order to make people unperceived. While in this paper, a new method was tried. We succeeded in making the visual stimuli unseen by adjusting the color of both the visual stimuli and the LED screen. The background color of LED screen is white (R:255,G:255,B:255）and the color of visual stimuli is very similar to white(R:248,G:248,B:248）. The visual stimuli were below the fixation point (+) and presented together with the fixation point, 1000ms each time. Subliminal auditory signal was achieved through controlling sound intensity of background sound and target signal. In our experiment, the sound intensity difference between them was 30db. The song Spring from Bandari was selected as background sound. The contents of subliminal stimuli were “Choose A” or “Choose B”. When the experiment was finished, each participant was asked whether he (or she) had seen or heard the content of subthreshold stimulation during the whole experiment. All the participants answered “no”.

C. *Experimental material*

In the classical Ellsberg’s simplest illustration, two urns are filled with red and black balls, Urn A containing an unknown ratio of 100 red and black balls, randomly mixed and Urn B containing 50red and 50 black balls, randomly mixed. A decision maker chooses a color (red or black) and an urn (A or B) from which to make a blind drawing and wins a prize if a ball of the chosen color is drawn. A large majority of decision makers strictly prefer the known-risk Urn B to the ambiguous Urn A, irrespective of the preferred color[6]. This paper used a slightly changed paradigm of Ellsberg paradox, the main changes were the total number of balls (three levels: 10, 50, 100) and the ratio of red balls in urn A (three levels: 0-100%, 20-80%, 40-60%). Thus, there were a total of 9 ambiguity decision-making scenes, and in previous studies it was proved that the 9 scenes were homogeneous. In each decision-making scene, whether the total number of balls or the ratio of red balls in urn A would be changed. Fig. 1 presents the form of decision-making scene. The last point should be noted was that participants were able to get additional award if they made a blind drawing of red ball in this experiment.

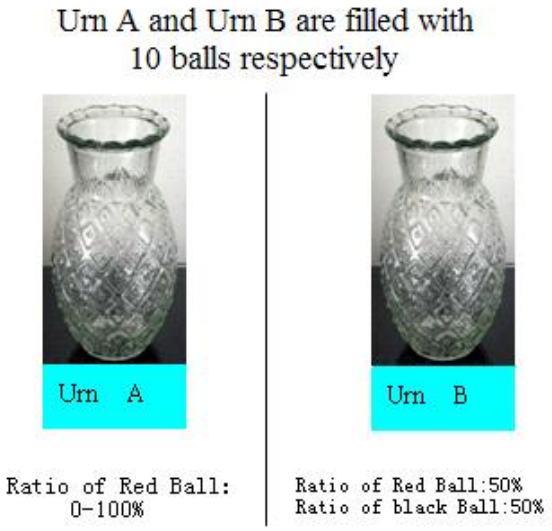

Fig.1. The form of ambiguity decision-making scene

D. *Experimental design*

1) Independent variables

The experimental design included one within-subjects independent variable. The variable was the kind of subliminal signal, including three levels: no subliminal signal, visual subliminal signal and auditory subliminal signal.

2) Response method

Participants were told to response by keyboard as quickly as possible. That is to say, if you want to choose urn A, please hit the keyboard A; and when you want to choose urn B, just hit the keyboard B.

3) Dependent variables

The dependent variables used to measure decision-making were preferred choice (A or B) and response time (defined as the time between the presence of each scene of ambiguity decision and the participants hitting the keyboard A or B).These two measures allowed for assessing the preference and speed of ambiguity decision making.

E. *Experimental procedures and order of the trials*

The participants were randomly divided into two groups according to sex and age, each group included 17 members. One group received the subliminal signal as “Choose A”, and the other group received “Choose B”. The experiment was conducted in standard behavior laboratory. Participants received 4 practice trials in order to become familiar with the task and the respond method. These practice trials were followed by 90 test trials consisting of 10 replications for each of the nine different decision-making scenes. And the 90 test trials were divided into three blocks, 30 trials in each block. The three blocks

were corresponded to the following three experimental conditions: no subliminal signal, visual subliminal signal and auditory subliminal signal. The experimental sequence was balanced between all the 34 participants and breaks from testing were provided between blocks. Participants decided the resting time according to their own need.

III. RESULTS

A. *Data processing*

All data collected in this experiment were valid and the SPSS 18.0 statistical package was used for analysis.

B. *Preferred choice*

1) The group with subliminal signal as "Choose A"

This group was provided with subliminal information as "Choose A" either through the vision channel or auditory channel. A one-way analysis of variance was conducted to explore the impact of subthreshold signal. The results showed that there were significant differences in participants' decision-making preferences（p =0.077）(Table 2).Under the influence of visual subliminal signal, the mean percentage of selecting urn A was higher than the remaining two experimental conditions. Follow-up pairwise comparisons of these three means yielded significant results (p =0.028) only between the condition of no subliminal signal and visual subliminal signal.

2)The group with subliminal signal as "Choose B"

This group was provided with subliminal information as "Choose B" either through the vision channel or auditory channel. A one-way analysis of variance was conducted to explore the impact of subthreshold signal. The results showed that there were significant differences in participants' decision-making preferences（p =0.043）(Table 2).Under the influence of visual subliminal signal, the mean percentage of selecting urn B was higher than the remaining two experimental conditions. Follow-up pairwise comparisons of these three means yielded significant results (p =0.016) only between the condition of no subliminal signal and visual subliminal signal.

Table 2. Ratio of selecting urn A under different conditions (N=17)

	Percentage of selecting urn A (%)	
	Mean	SD
no subliminal signal	46.41	15.53
visual subliminal signal (Choose A)	50.20	17.06
auditory subliminal signal (Choose A)	58.63	14.34

Table 3. Ratio of selecting urn B under different conditions （N=17）

	Percentage of selecting urn B (%)	
	Mean	SD
no subliminal signal	51.39	16.20
visual subliminal signal (Choose B)	53.92	18.11
auditory subliminal signal (Choose B)	64.11	13.37

C. *Response time*

1) The group with subliminal signal as "Choose A"

This group was provided with subliminal information as "Choose A" either through the vision channel or auditory channel. The mean response time for no subliminal signal, visual subliminal signal, auditory subliminal signal were 2733.32 ms, 2809.18ms, 2791.05 ms, respectively. The main effect on response time was not significant (p>0.10).

2) The group with subliminal signal as "Choose B"

This group was provided with subliminal information as "Choose B" either through the vision channel or auditory channel. The mean response time for no subliminal signal, visual subliminal signal, auditory subliminal signal were 2822.58 ms, 2698.71 ms, 2775.92 ms, respectively. The main effect on response time was not significant (p>0.10).

IV. DISCUSSION AND CONCLUSIONS

Subliminal perception is a kind of unconscious perception, people can not consciously perceived. Previous studies have found that the level of unconscious processing is relatively low. That is to say, with the influence of unconscious perception, one can process the physical characteristics of the word, without understanding the meaning[7]. In our experiment, the presentation of subliminal stimuli was different from traditional unconscious stimuli forms,and a new method was tried. We made the visual stimuli unseen by adjusting the color of both the visual stimuli and the LED screen. Through the results of this paper, we can observe that although all the participants do not see the visual information, but they are significantly affected by those unseen word when making decision. Ambiguity aversion has been investigated by psychologists since Ellsberg (1961) noted that decisions makers tend to prefer taking gambles with known-risk probabilities over equivalent gambles with ambiguous probabilities[8]. In this paper, participants also showed ambiguity aversion and the mean percentage of selecting

urn A is 48.90%, which is close to the percentage (46.92%) reported by previous literature[9]. While the participants received subliminal visual stimuli, their preferred choice changed with the content of those unseen stimuli, showing a clear trend.

In regard to subliminal auditory stimulus, they did not produce significant effects in this experiment. It may be due to the sound intensity, which is probably too low for human. This reminds us of a common problem about subliminal perception. The so-called subliminal perception is largely based on people's subjective experience and the subjective feeling will keep varying due to different persons or different surroundings.So, in future experiments, we will measure each person's hearing threshold and then set different sound intensity for them.

In summary, this paper indicates that subliminal vision stimuli provide a promising way to affect human's decision making. This finding has some particular meaning for the development of future decision making system， which will provide the scientific foundation for engineers. The function of current decision making system is to provide users with large amounts of data to support decision-making. The system mainly consists of human-machine interface and backstage database. The human-machine interface is responsible for providing a platform for users to communicate with the system, and human's operations or commands are accepted by it. The task of backstage database is data acquisition, analysis and information fusion. According to the results of this study, We can imagine that the future decision support system is expected to systematically evaluate and change people's decision-making. It only needs engineers to embed a particular decision-making intervention module in the system, in addition, the function of intervention module can be flexibly set according to different intention.

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