

High work-related stress employees' Stroop effect on danger-related words

Qianru Jiang *

School of Education and Science, Chongqing Normal University, Chongqing, China

* Corresponding Author Email: 2017110503074@stu.cqnu.edu.cn

Abstract. With the increasingly fierce competition caused by economic globalization, the physical and mental health of employees' work-related stress has become an important topic. The study sets danger/neutral-related words as dependent variables in a Stroop paradigm task and focuses on the reaction time and accuracy rate to examine what changes would happen to high work-related stress employees' cognitive process. The results show that the main effect of the word is significant: participants' Accuracy Rate of danger-related words is significantly lower than the neutral words, and their Reaction Time of danger-related words is longer. The impact of color and word interaction on the Accuracy Rate is significant: The Accuracy Rate of danger-related words at red levels is higher than the danger-related words at the blue level, and the Accuracy Rate of neutral words at red level is higher than neutral words at the blue level. The study also reveals that high work-related stress has a significant negative impact on the cognitive process as the low wake-up state makes a significant interference on cognitive capacities.

Keywords: Work-related stress; Stroop paradigm task; Danger-related words.

1. Introduction

Work-related stress is a system reaction when the stressors persistently threaten individuals' workplace behaviors and elicit a series of physiological, psychological and behavioral responses based on individual differences [1]. Work-related stress can positively/negatively influence one's working state. The problems brought by work-related stress not only interplay with personal life, work quality and work performance, but also closely affect the overall efficiency and vitality of the organization [2]. Individuals who have been in a state of high work-related stress for a long time usually have obvious changes, and these changes cause negative effects. For example, work-related stress can lead to a significant decrease in life quality for the police group [3]; it can also increase the risk of gaining health problems for clinical nurses [4]; in addition, work-related stress also significantly affects cognitive discrimination of college teachers [5].

With the further development of economic globalization, the competition of private enterprises is becoming increasingly fierce, and private enterprise employees have to be more urgent to increase their professionalism and competitiveness through learning professional knowledge and expanding the customer market. The work-related stress is likely to exceed many people's own response capacity. At present, the research of most scholars on the impact of work-related stress is more concentrated in state-owned enterprises, grass-roots civil servants, nurses, doctors, teachers, athletes, etc., and less concentrated in private enterprises [6-11]. Exploring the characteristics of the cognitive process of private enterprise employees under high work-related stress can help private enterprises and their employees to properly and effectively handle the impact of work-related stress, and achieve the goal of a 'win-win' between employees' physical and mental health and organizational performance.

Perception load theory believes that the individual's cognitive capacities are limited, and whether the distraction is processed depends on the mission's perceptual load [12]. Under low perceptual load conditions, individuals have extra attention to process distractor, and less to filter the distractor, so the distractor will interfere with task processing; under high-conscious load conditions, one may pay attention to the use of resources in task-related processing, and fully filter the distractor. If there are no excessive resources to process the distractor, the interference effect will be reduced or even disappeared [13]. However, some studies believe that regardless of the load of the task, negative

stimuli will continue to compete with the current task and interfere with task processing [14]. Because the processing of negative emotional stimulation is automated, there is no need to pay attention to resources. Under the two perceptual loads of high and low consciousness, negative distractors have greater interference effects than neutral distractors. For example, patients diagnosed with phobia syndromes are adjusted without mission-not-mixed perception of pictures that make them fear [15].

The cognitive process is affected by not only negative emotional stimuli, but also the physical and mental state and behaviors under stressful conditions [16]. The cognitive process under high work-related stress will cause an imbalance of resource allocation. When the cognitive process of an individual is disturbed, the reaction to a stimulus will be weakened. Specifically, as one of the most basic stimuli in the living environment, colors affect the emotions of animals and humans [17]. In terms of emotional awakening, most behavioral experiments and skin electricity experiments found that the long wave color (such as red) has a higher awakening effect than the short-wave color (such as blue), which means red can elicit more emotional responses than blue [18].

This study aims to explore the characteristics of cognitive resource distribution of individuals with high work-related stress, the negative emotional stimulation process, and the characteristics of the awakening effect of red and blue. It utilizes the Stroop paradigm of danger-related/neutral words as the material and analyzes participants' Accuracy Rate (AR) and Reaction Time (RT) when discriminating the red and blue colors. The research assumes that in the Stroop task, AR of recognition of participants with high work-related stress on danger-related words is significantly lower than it on neutral words.

2. Methodology

2.1 Participants

Table 1. Sample demographics

	Total
Number of participants	33
Female=yes(%)	22(67)
Education level(%)	
Specialist	5(15)
Undergraduate	28(85)
Marital Status(%)	
Unmarried	4(12)
Married	27(82)
Divorce	2(6)
Years of work(%)	
≤ 3 years	2(6)
>3 & ≤5 years	10(30)
>5 & ≤10 years	15(45)
> 10 years	6(19)
Position(%)	
General Employee	23(70)
Middle and Senior Management	10(30)
Monthly Revenue(%)	
≤ 3K	3(9)
> 3K & ≤ 6K	14(42)
> 6K & ≤ 9K	5(15)
> 9K & ≤ 12K	8(24)
> 12K	3(9)
Work Stress Scale Score(M±SD)	130.72(6.54)

The questionnaire survey method was used to screen participants who will participate in the formal experiment. In the questionnaire survey, in order to ensure the credibility of the research and reduce

random errors, the "Work-related Stress Table" compiled by Jiang.qinru et al in 2020 conducted large sample surveys of all employees of 9 private enterprises [19]. After analyzing the questionnaire survey results, among the 356 participants participating in the "Work-related Stress Table" survey, 33 participants with the highest score of "Work-related Stress Table" participated in the formal experiment (see table 1). The purpose is to ensure that participants in the formal experiments are at a high level of work-related stress.

2.2 Danger-Related Words Stroop (DRWS) task

The DRWS task measures perceptual control of hazard information at high-stress levels. On each trial, the subjects decide whether the color of each word is red or blue, and respond by pressing the keyboard keys, and pressing the F key for red and the J key for blue. The task consists of 24 trials divided into two blocks, each containing 12 trials. Before the formal experiment, there is a practice block, which contains 4 trials, and the experimental materials are different from the formal experiment. Each block of formal experiments has 50% congruent trials (danger-related words with red/neutral words with blue) and 50% incongruent trials (danger-related words with blue/neutral words with red). There are 12 danger-related words and 12 neutral words in the experiment. All words are ranked based on danger-relatedness by high work-related stress subjects who do not participate in the formal experiment. Six of the danger-related words are in red, and the other six are in blue; six neutral words are in red, and the other six are in blue. Stimuli are presented using a 22-inch color display screen with a resolution of 1920×1080 and a refresh rate of 60 Hz. The experiment is compiled with PsychoPy22.0 and runs on the Windows 10 operating system. In order to test the true reflection of the subjects under high work-related stress, the subjects complete the entire experimental data collection process alone in the fully enclosed conference room of their company. After learning about the experimental procedure and instructions, the subjects put their hands on the keyboard to start the experiment. As shown in Figure 1, the fixation screen is first presented for 500ms, and then the stimulus screen is presented for 1000ms. The participants must respond according to the color of the words within 1000ms, by pressing the "F" key for red and the "J" key for blue. The next fixation screen and stimuli are presented regardless of whether the subject respond or not. All materials are presented completely randomly without repetition.

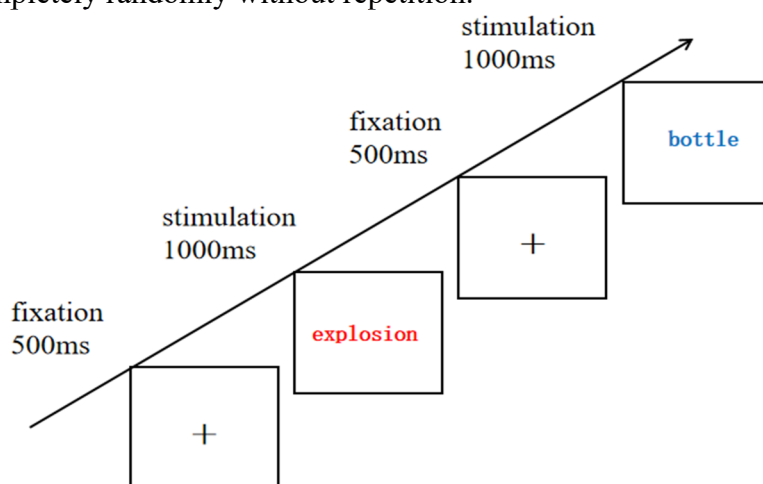


Fig. 1 Experimental flow chart

2.3 Data analysis

First, in order to ensure the reliability of the data, the trials with a reaction time of less than 200ms were deleted, and the trials with three standard deviations above and below the average reaction time of each participant were deleted [20]. The study used the "word" and "color" indicators, and did not adopt the method of analyzing the data analysis based on the deletion error reaction. Secondly, for each participant, the study calculated the performance in the mean RT and AR in each of four conditions. The conditions average from all participants explored into SPSS20.0 for repeating

measures ANOVAs testing to test the predicted “2 (word: danger-related/neutral) $\times$ 2 (color: red/blue)” interaction between words and color on the RT and AR. Finally, the study analyzed the difference between the single factors for the RT and AR, and examined the response characteristics of the participants under different conditions.

3. Results

To test the predicted effects of congruency, distractor valence, and the interaction between congruency and frequency on performance, the researcher conducted repeated measure ANOVAs with the TR and AR, where the words (danger-related/neutral) and color (red/blue) were used as the independent variable (See Table 2 and Fig. 2).

Table 2. Means by task manipulation conditions in the Danger-Related Words Stroop task

Numble	Accuracy Rate(SD)[%]	Reaction Time(SD)[ms]
Words		
Danger-Related Words	201(51)	60.4(15)
Neutral Words	365(92)	58.8(16)
Color		
Red	287(73)	58.2(16)
Blue	279(70)	56.7(16)
Words*Color		
Red*Danger-related(congruent)	104(53)	60.72(1.10)
Red*Neutral(incongruent)	183(93)	58.78(1.10)
Blue*Danger-related(incongruent)	97(49)	60.10(1.10)
Blue*Neutral(congruent)	182(92)	55.25(1.10)

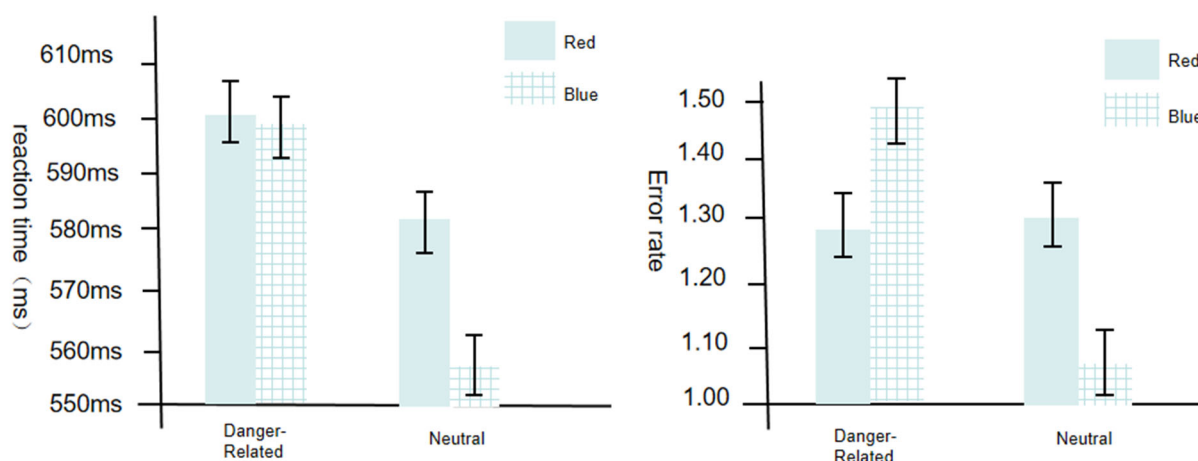


Fig. 2 Bar plot of condition means for Reaction Time and Accuracy Rate.

The analysis of the repeated measure ANOVAs for the RT indicates that the main effect of the vocabulary is significant, $F(1,33) = 9.536$, $p = .002 < .01$, $\eta^2 = .012$, and the RT to the danger-related words (604.1ms) is slower than to the neutral words (570.2ms); the main effect of the color is not significant, $F(1,33) = 1.724$, $P = 0.190$. The analysis of the repeated measure ANOVAs for the AR indicates that the main effect of the words is significant, $F(1,33) = 33.000$, $p = .000 < .000$, $\eta^2 = .040$, and the AR of the danger-related words (51) is lower than the AR to the neutral words (92); the main effect of the color is not significant, $F(1,33) = 1.724$, $P = 0.190$. However, the simple effect of Blue conditions is significant, $F(1,33) = 9.744$, $p = .002 < .01$, $\eta^2 = .012$, and the AR (109) under blue conditions is significantly lower than the red conditions AR (207) (See Table 3, Table 4 and Table 5).

Table 3. ANOVA Table for Reaction Time

Variable	DF	F-value	η^2	p-value
Words	1	9.536	.012	.002(<.01)
Danger-related	1	.157	.000	.692
Neutral	1	5.161	.007	.023(<.05)
Color	1	3.559	.002	.060
Red	1	1.552	.002	.213
Blue	1	9.744	.012	.002(<.01)

Table 4. ANOVA Table for Accuracy Rate

Variable	DF	F-value	η^2	p-value
Words	1	33.006	.040	.000(<.000)
Danger-related	1	12.125	.015	.001(<.01)
Neutral	1	28.507	.035	.000(<.000)
Color	1	1.724	.002	.190
Red	1	.121	.000	.729
Blue	1	71.792	.083	.000(<.000)

Table 5. Further Analysis of Words * Color

Variable	DF	F-value	η^2	p-value
Reaction time				
Words * Color	1	1.724	.002	.185
Danger-related*color	1	.157	.000	.692
Neutral*color	1	5.161	.007	.023(<.05)
Accuracy Rate				
Words * Color	1	38.907	.047	.000(<.000)
Danger-related*color	1	12.125	.015	.001(<.01)
Neutral*color	1	28.507	.035	.000(<.000)

Further analysis of the AR shows that there is interaction between words and color, $F(1,33) = 38.907$, $P = .000 < .000$, $\eta^2 = 0.047$. In detail, the AR of danger-related words under red conditions (53) is significantly higher than the accuracy of dangerous words under blue conditions (49), $f(1,33) = 12.125$, $P = .001 < .01$, $\eta^2 = 0.015$; the AR of neutral-related words under red conditions (93) is significantly higher than the neutral words under blue conditions (92), $F(1,33) = 28.507$, $p = .000 < .000$, $\eta^2 = 0.035$ (See Table 2 and Table 5). In addition, further analysis of the Reaction Time shows that the interaction between words and color is not significant, $f(1,33) = 1.724$, $P = 0.185$. This result shows that there is no interplay between speed and accuracy, and the analysis based on AR is effective (See Table 5).

4. Discussion

This study discusses whether the AR and RT of danger-related words and neutral words colors are significantly different under the influence of high work-related stress. The employees of private enterprises were tested, the word color recognition task was completed in the Stroop paradigm transformer, and the independent variable of words(danger-related/neutral) was introduced.

In the main effect analysis results of the repeated measure ANOVAs, the primary effects of the words are significant in the RT and AR. The AR of danger-related words is significantly lower than that of neutral words, and the RT of danger-related words is significantly longer than neutral words. Based on the balance of speed and accuracy, the slower the rate, the higher the accuracy. However, the longer reaction time does not indicate higher accuracy. In summary, the analysis results based on the RT and the AR are effective, which means that the hypothesis is established. According to the

conscious selection mechanism, the recognition of the color is the current task, and the nature of words(danger-related/neutral) will interfere with the current task. Under normal circumstances, in the high load condition, there are not enough resources to be assigned to tasks other than color discrimination, and the interference factor will not be activated. The RT and AR will not be significantly different in terms of words. However, due to the impact of high work-related stress, participants may not be able to control the distribution of resources, or there are not enough resources to suppress the startup effect, or more resources are needed to suppress the startup effect of danger-related words. The startup effect of danger-related words may interfere with the color discrimination task to a certain extent. As a result, the speed of danger-related words is significantly longer than that of neutral words when discriminating the color. Under the influence of high work-related stress, the loads in emotion and cognition have increased, resulting in the AR has not increased, even if the RT increased.

In addition, although the main effect of the color is not significant in the RT and AR, the simple effect on the blue level is significant. At the blue level, the RT of the color discrimination in danger-related words is significantly slower than in neutral words, and the AR is lower. A possible explanation is the degree of emotional awakening is lower, and there is no need for many resources in the selection mechanism of perception to suppress the startup effect. Therefore, the nature of vocabulary may be more obvious in the results. On the other hand, the high work-related stress will lead participants to produce more negative emotions, resulting in the failure of the selection mechanism of perception. Even in the high load condition, there are not enough resources to have a startup effect.

Finally, in the analysis of the AR, the interaction between colors and words is significant. The AR of danger-related words under red conditions is significantly higher than the AR of danger-related words under blue conditions and the AR of neutral words under red conditions is significantly higher than the neutral words AR under blue conditions. These findings can attribute to the higher degree of awakening. To be specific, the red color is more stress-prone. When participants are under work-related stress, the red startup effect is more obvious. In the conscious selection mechanism, when there are sufficient resources to determine the current task (color), there are insufficient resources for startup interference, which inhibits the generating effect of word properties.

5. Conclusion

In this study, the employees of private enterprises with high work-related stress participated in the DRWS task. The investigation found that when people are under high work-related stress, they will take longer time and make more mistakes when recognizing danger-related words. Specifically, when the words are presented in blue, participants will take more time and make more mistakes when recognizing danger-related words. Besides, the impact of color and word interaction on the AR is significant: the AR of danger-related words at red levels is higher than the danger-related words at the blue level and the AR of neutral words at red level is higher than neutral words at the blue level. In summary, the high work-related stress brings a significant impact on the cognitive processing process of employees. At least it can be learned that the employee's danger-related words and color perception process under high work-related stress have undergone negative changes. In the work scenario, blue may not be applied to text materials for high-pressure working environments and in high-pressure environment, stimuli other than text may be needed to remind the risk factors in the environment. The research has not further explored whether factors such as pictures, videos, and other dangerous stimuli (closer to actual work and life scenes) except for words will bring greater negative reactions to employees.

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