Factors Research on EEG Signal Analysis of the Willingness of Error Reporting

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Abstract. Error events and near-miss events often appear in our daily life and are featured by strong concealment, which may become a hot-bed of major accidents. From the perspective of error control, enterprises need to integrate relevant information to deal with those events so as to reduce their negative effects to the enterprise. The source of error information is error report. In order to find the measures of improving the willingness for report errors, mixed experiments designed for both within the subject and in between two subjects have been applied, together with related potentials (ERPs), to explore the effect of different motivation mechanism on the mechanism of self error report. The research shows that as far as the willingness of error report is concerned, the positive monetary incentive (bonus) often leads to greater FRN and P300 amplitudes, compared to the negative stimulus (penalty), whereas positive motivation is more effective than negative motivation when provoking extrinsic motivation. Meanwhile, when increasing the self-selection right of error report, i.e., when voluntary error report system is applied, the inner motivation of error report will increase accordingly and more attention will be paid to the incentive. Hence the effect of incentive will be improved.

Keywords: Error reporting intention · Event related potentials · Extrinsic motivation · Intrinsic motivation

1 Introduction

With the rapid economic development, the errors problem of also exist in the enterprise. From the beginning, the enterprise in order to eliminate the loss caused by the error, often used to deal with the error to avoid: that is, when the error event signs, from the source to kill all the possibility of errors occur, thereby reducing the occurrence of errors. However, due to various reasons, the error event is always inevitable. There are some limitations to error avoidance, such as the inability to eliminate or predict all errors, and the invariance of rules. In fact, the error is not only for the enterprise losses. According to modern error management theory, when the error event occurs, the error analysis and analysis to get relevant information, and organizational learning, sharing, can reduce the probability of the same error event recurrence; and the relevant error information to learn, not only Help to open the train of thought, and in the future work will stimulate his desire for innovation [2].

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Therefore, companies need to establish some incentive mechanism to improve the staff to report the proportion of errors. From the external motivation, reward and punishment are powerful motivating factors, pre-researchers to conceal the incentive mechanism used in the more concentrated in the punishment of this level, that is, the person responsible for the incident and related events to conceal. False positives, late reports, false negative behavior punishment, increase the cost of such acts, and thus encourage individual initiative to report the error [3], but the effectiveness of this approach still need further empirical, experimental test. There are some organizations trying to volunteer to report the event of the incident exemption incentives. Even some studies suggest that reward is more effective than punishment [4].

In 2014, Shui-cheng Tian et al. and other research on the coal mine risk trillion events, risk management and risk trillion events reported voluntarily willing to report the relevant content of the study, which is the earlier report on the field of coal mine will study [5–8]. in the coal mine risk trillion incident voluntarily report the factors affecting factors, "reporting the consequences" of the dimensional indicators, the fear of punishment is the impact of miners reported dangerous events of the enthusiasm of the important factors, so the risk of trillion incident Retribution to promote "active reporting, non-punitive" principle, and the establishment of reporting reward system [9].

From the motivation of error reporting to individuals, the incentive mechanism used by the researchers from the previous period mostly focused on the punishment level. Recently, the researchers advocated rewarding the error reporting behavior, and believed that the reward and punishment of the incentive factors are effectiveness, and even more effective way to reward. However, most of these studies are based on the organization to study the willingness to report the error, from the level of individual neural mechanisms of error self-report motivation intensity is relatively small; from the research method, But also rarely from people's physiological and psychological mechanisms into the study to prove that incentive incentives than punishment more effective, and given experimental data to confirm. Therefore, use the neural management to research on the individual level of error report willingness. By studying the mechanism of cognitive activity in the brain, it is more accurate to record the EEG data generated by the externally applied influence, quantitatively analyze the data, and obtain the conclusion from the measured data, which is relatively objective [10, 11]. Thus, the FRN component and the P300 component were selected for the study.

In the process of studying on the FRN components, the FRN component is also induced by the fact that the feedback is not the same as expected. This shows that, even if the feedback is rewarded, but if they do not meet the psychological expectations of the subjects, will still send a clear FRN components. In the research of 2007, Oliveira et al. [12] designed an experimental task to verify the rationality of the expected violation of the hypothesis. The experiment is divided into two experiments, the experimental materials are required to respond to a constant movement of the light point, the difference between the two experiments is that after the completion of the experiment in the subjects need to respond to their own just after the results of the behavior do an estimate, and then give the results of feedback procedures, and experimental two direct skip their assessment of the stage, the program directly showing the feedback results. According to the experimental results, it can be seen that FRN is induced only when the predicted results do not match the feedback results,

regardless of the task completion results. Previous studies have confirmed that FRN components can reflect the degree of satisfaction with the results and the size of the expected gap, and are not sensitive to the true response. The FRN component can therefore be used as a measure of the intensity of motivations induced by different stimuli.

In the course of studying the P300 component, many experimental results can show that the P300 component is associated with the attention resource allocation. In 1986, studies by Donchin et al. [13] have shown that the P300 component is related to the allocation of attention resources. The study shows that the P300 component and attention to the relationship between the allocation of resources, designed a dual-task model of the experimental program, and many of the results in the subsequent proof of P300 component amplitude and Attention assigned to the size of. The study of Leng and Zhou's in 2010, it was also a pattern of simultaneous multi-tasking: a pair of friends and a stranger were simultaneously tested as gamblers, and one of the friends used to take the EEG caps for experiments, The subject was told before the experiment in addition to the need to complete their own tasks, but also need to pay attention to their friends there is another stranger in the performance of the task. The results are discussed, giving the view that: subjects and their friends a total of emotional stronger, so give friends more attention [15]. Therefore, it also shows that the P300 component can well reflect the individual's attention resource allocation. The same studies of Itagaki and Katayama [17] and Fukushima [16] and Hiraki (2009) also demonstrate this cognitive phenomenon associated with the allocation of attention resources.

In this paper, event-related potential techniques in neuroscience are used to analyze the factors that affect the motivation of individual error reporting. The purpose of this study is to find out whether the incentive of reward is more effective than punishment and whether the right of self-determination affects the intrinsic motivation of error reporting. Stronger, and provide physical evidence of the data.

2 Method

2.1 Experimental Design Framework

This research use three different stimulus methods were selected: positive, negative, and non-stimulating. Individuals were rewarded, punished or unresponsive for random error reporting. The experiment was divided into two groups. Group: experimental group and control group, the experimental group for the voluntary reporting group, the control group for the mandatory reporting group, the individual's self-determination as independent variables, self-determined behavior of error reporting behavior of intrinsic motivation.

2.2 Experimental Subjects

In this study, 20 postgraduates were recruited from Xi'an University of Science and Technology as subjects aged 20–27 years (mean age 24.9 years, mean SD 1.86). In order to reduce the physiological factors caused by the brain on the EEG, the right eye;

Data accuracy. So the subjects cannot stay up late, cannot drink high-caffeine beverages.

2.3 Process of Experiment

This research program is realized through E-Basic language and Script language programming, the language is written in E-Prime2.0 in the Inline object. Experiments using the software implementation program (E-Run) presentation of stimulus material, while recording the relevant behavior data.

The experimental procedure is divided into two blocks. The first Block, which is the first stage of the experiment showed 200 trials, the subjects cannot be free to end the experiment; 200 trial will pop up after an interface to remind the subjects can take a break, and then free to choose willing to continue the experiment. If the subjects are going to the second phase. The participants can finish the experiment at any time (the maximum number of trials in the second stage is 200) (Fig. 1).

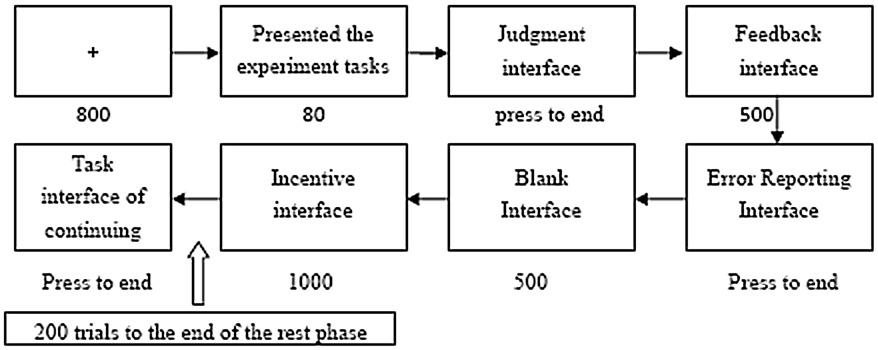

Fig. 1. The experimental stimulus flow chart (unit: ms)

The Neuron EEG/ERP event-related potential system was used to collect EEG signals.

3 Analysis of Willingness to Influence on Experimental Data

According to statistical principles: for the behavioral data, the t test between groups of experimental data analysis. For EEG data, the three groups of experiments in the use of stimulation methods and electrode points ANOVA analysis of variance analysis of data processing. The variance analysis method was used to analyze the data, and t-test was used to analyze the difference amplitude data.

3.1 Behavioral Data Analysis

The number of completed experiments in different experimental groups in the second stage of the experiment (the subjects could finish the experiment voluntarily) was statistically analyzed. The results showed that 48.60 experiments were carried out in the experimental group, and the variance was 15.01. In the control group, 20.40 experiments were conducted on average, and the variance was 11.02.

3.2 EEG Data Analysis

The Analysis of FRN Components. In the forehead and central regions of the brain, the FRN component appears in the ACC region, and the amplitude of the FRN component in this region is relatively large. Therefore, we selected the ACC region of the Fl, FZ, F2, FCl, FC2, C1, CZ and C2 a total of eight electrode points for analysis. According to the analysis of EEG data, the average amplitude of 200–250 ms is selected as the amplitude of the FRN component, and the data are analyzed statistically.

(8 feedback points: F1, FZ, F2, FC1, FC2, C1, and C2) for the average amplitudes of the FRN components (between 200 and 250 ms) 3 (3 feedbacks: bonus, penalty and no response) CZ and C2) $\times$ 2 (two experimental groups: experimental group and control group) to do mixed measurement of variance analysis grouping factors were two groups of experimental subjects (experimental group and control group), repeated measurements of the level of the electrode (9) And feedback (three). The results show that the amplitude of the FRN component has a significant main effect on the three feedbacks: $F(1, 19) = 3.54$, $p < 0.05$; no major effect is found between the experimental groups and the electrodes.

It was found that the FRN amplitudes ($M = 5.51$, $SD = 0.52$) of the positive excitation in the experimental group were significantly larger than those of the negative excitation ($M = 3.22$, $SD = 0.67$), $p = 0.000 < 0.05$; The FRN amplitudes of unstimulated FRN amplitudes were significantly larger than those of unstimulated FRN amplitudes ($M = 4.47$, $SD = 0.95$), $p = 0.04 < 0.05$. ($M = 5.44$, $SD = 0.49$) was significantly greater than the FRN amplitude of negative excitation ($M = 3.10$, $SD = 0.58$), $p = 0.000 < 0.05$ in the control group, FRN of positive excitation $P = 0.024 < 0.05$. The FRN amplitude of unstimulated FRN amplitude is significantly larger than that of negative excitation, $p = 0.023 < 0.05$, and the amplitude of unstimulated FRN is larger than that of unstirred FRN ($M = 4.32$, $SD = 1.23$).

The FN, FC1, and CZ, which are the most prominent of the eight FRN components selected for the study, are plotted as shown in Figs. 2 and 3. Among them, FRN components induced by different excitation conditions are boxed out.

The Analysis of the P300 Composition. From the literature, we found that the P300 component in the posterior region of the brain was more pronounced and the amplitudes were greater. Therefore, we selected nine central electrodes (C1, CZ, C2, CP1, CPZ, CP2, P1, PZ, and P2). The time domain of the P300 component was selected, and the waveforms of the P300 were selected and observed and analyzed. The time window was 300–350 ms, and the voltage value of the P300 component in this time period was

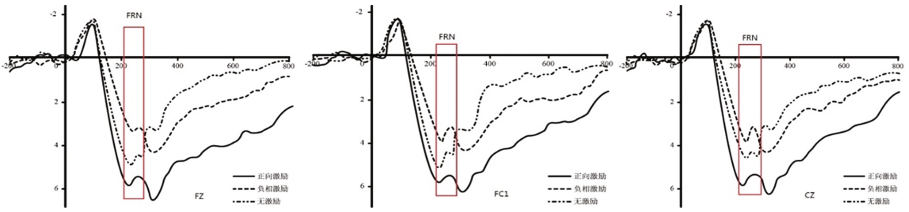

Fig. 2. FRN waveforms of the experimental group FZ, FC1 and C points

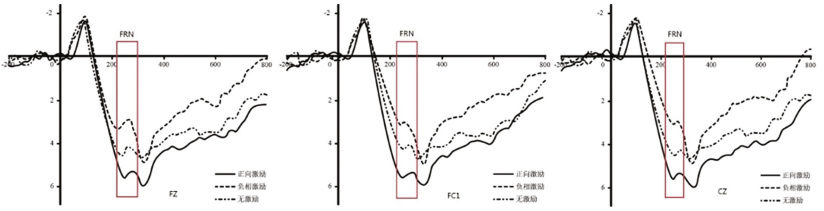

Fig. 3. FRN waveforms of FZ, FC1 and C points in the control group

superimposed and averaged to obtain the component The average amplitude value, and use this data for statistical analysis.

In the same way, the average amplitude of the P300 component in the selected time window is 3 (3 feedbacks: bonus, penalty, and no response) × 8 (8 electrode points: C1, CZ, C2, CP1, CPZ, CP2, P1, PZ and P2) × 2 (two experimental groups: experimental group and control group) to do mixed measurement of variance analysis. Similar to the FRN component analysis model, the grouping factors were two groups of subjects (with and without option), and the repeated group level was electrode (nine) and feedback (three). The results showed that the amplitude of P300 had a significant main effect on the three feedbacks: $F(1, 19) = 2.88$, $p < 0.05$; there was no main effect at the electrode point; there was interaction between the feedback type and the experimental group, $19) = 3.39$, $p < 0.05$.

In order to further analyze the relationship of the three feedback types on the 300 components, paired T-test analysis of the three feedback results was done. The control group experimental group, the results of three kinds of feedback and electrode pairs does T test analysis.

The results showed that the amplitudes of P300 components induced by positive excitation ($M = 6.58$, $SD = 0.37$) were significantly larger than those of P300 ($M = 4.11$, $SD = 0.35$), $p = 0.000 < 0.05$; ($P = 0.000 < 0.05$). The P300 amplitude of the unstimulated P300 amplitude is significantly smaller than the P300 amplitude of the negative excitation ($p = 0.001 < 0.05$). In the control group, the P300 amplitude of positive excitation ($M = 5.97$, $SD = 0.87$) was significantly greater than that of negative excitation ($P = 0.001$, $P = 0.001$; ($P = 0.007 < 0.05$). There was no significant difference between the amplitude of P300 and the amplitude of negative excitation ($p = 0.28 > 0.05$), and the amplitude of P300 was not significantly different from that of no excitation ($M = 4.38$, $SD = 0.69$).

The P300 component of the nine electrode points selected for the study was plotted with three distinct CZ, CPZ, and PZ electrode points, as shown in Figs. 4 and 5, where the author box out the P300 components induced by different excitation conditions.

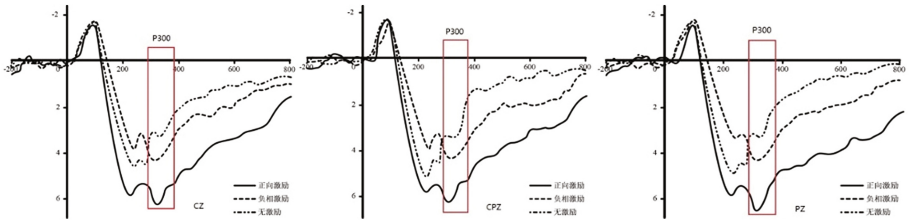

Fig. 4. P300 waveforms of the CZ, CPZ and P points in the experimental group

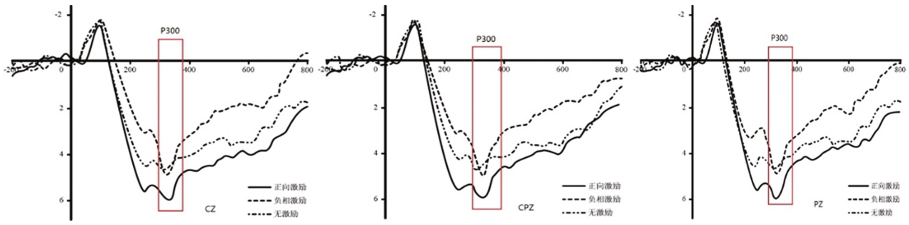

Fig. 5. The P300 waveform of the CZ, CPZ and P points in the control group

There is an interaction effect between the feedback type and the experimental group. Therefore, the p300 amplitudes of positive stimulus feedback P300 of the experimental group were significantly larger than that of the positive stimulus feedback P300 ($p = 0.04 < 0.05$), but for the experimental group The P300 amplitude of the negative stimulus feedback and P300 amplitude of the non-excitation feedback were significantly smaller than those of the negative stimulus feedback P300 ($p = 0.01 < 0.05$) and P300 amplitude ($p = 0.017 < 0.05$). Similarly, the experimental group in the three feedback excitation amplitude difference is greater than the control group of three feedback excitation amplitude difference.

4 Discussion

4.1 Behavioral Data Results Discussion

The experimental results showed that the number of tasks completed in the second stage of the experimental group was significantly greater than the number of tasks completed in the control group. In the experiment group, the intrinsic motivation intensity was greater than the mandatory report the intrinsic motivation of a task. It can also be argued that giving the subject a high degree of self-determination, for example, giving the participant the option of reporting his own error will produce a stronger task

intrinsic motivation than mandatory error reporting. Thus, the report shows that voluntary reporting mechanisms are more effective and more developmental than mandatory reporting.

4.2 EEG Data to Discuss the Results

Conclusions Related to FRN Composition. FRN amplitude has significant effect on three kinds of feedback results, but there is no main effect between different experimental groups and between electrode points. In experiment group and control group, the mean value of negative excitation results is higher than that of positive excitation and the result of non-excitation feedback is small. The FRN component is a negative trend-specific wave in the feedback phase of the results, so this paper discusses the motivation and cognitive evaluation. A large number of studies have shown that FRN components are more active in the anterior cingulated gurus (ACC) region, whereas ACC detects whether the resulting feedback is inconsistent with expectations, so the FRN component is also induced by feedback and expectation. In a 2007 study, Oliveira et al. designed an experimental task to verify the rationality of the expected violation of the hypothesis. According to the experimental results, it can be seen that the FRN components are induced only when the predicted results are not consistent with the given feedback results, even if the feedback results are positive feedback, so the FRN component reflects. The result of the feedback is different from the expected procedure [-]. For the theory of emotional motivation, Gehrig et al. showed that the amplitude of the FRN component induced by the feedback at the time of losing money was significantly larger than that of the winning FRN component. Researchers to discuss the conclusion, FRN component is actually the performance of the brain on different stimuli reflect different motives and emotions, or measure the intensity of motivation indicators. In contrast to negative feedback, positive feedback will induce a smaller FRN component amplitude, in fact, also proved that FRN components subject to the same subjective (such as Zhou, Z., etc.), relative to negative feedback, Emotional impact.

Thus, based on the experimental results, “the negative-excitation feedback results in a larger FRN-component amplitude than in the forward and no-excitation feedback results.” It can be seen that the subjects were more willing than the negative stimulus (penalty) (Reward), but in the feedback phase there is not the same as he expected feedback, there will be more significant negative wave waveform. The positive incentive (reward) is higher than the negative subjective incentive (punishment) and no incentive. It also shows that FRN can stably reflect the subjective evaluation of feedback results.

Beside,there was no significant difference in FRN amplitude between the two groups. However, in both experiments, the FRN amplitudes induced by the negative excitation (penalty) were significantly larger than those without excitation and positive excitation (reward).

Conclusions Related to P300 Composition. The method of analyzing the composition of P300 is the same as that of FRN. It is concluded that the amplitude of the P300

component has a significant main effect on the three kinds of feedback results, and the feedback type has an interaction effect with the experimental group. The mean P300 voltage of positive excitation is larger than that of negative excitation and no excitation, which indicates that the feedback result of positive excitation results in a larger P300 amplitude than non-excitation feedback and negative feedback. The result of the pairing test shows that the relationship between the amplitude and the amplitude is positive excitation > negative excitation > no excitation, both in experiment group and in control group. But the difference is that the P300 amplitude of the unstimulated P300 is significantly less than the P300 amplitude of the negative stimulus in the experimental group, while there is no significant difference between the P300 amplitude and the negative excitation in the control group.

P300 components can reflect the cognitive function of the brain, attention to how much the allocation of resources. The data show different degrees of personal cognition [22–24]. In the literature review, it is also suggested that many of the experimental results can reflect the evidence that the P300 component is associated with the attention resource allocation. Studies by Donchin et al. [13] have shown that the P300 component is related to the allocation of attention resources (during cognitive processing of stimuli). In this study, Donchin and other researchers in order to explore the P300 component and attention to the relationship between the allocation of resources, and after a lot of research results have proved that the P300 component amplitude and distribution of attention to the size of the results show that The more attention is paid to the current stimulus, the greater the amplitude of the P300 [25–27]. There is also an interpretation of the P300, that is, it is related to the effect of forward, is the target desire to achieve the target [28, 29].

In the present research results, the feedback of the positive stimulus (reward) induced a greater P300 amplitude than the negative (punish) and non-stimulated, and the P300 amplitude of the negative stimulus (penalty) was greater than the P300 amplitude. In contrast to the non-incentive, the negative incentive (punishment) is also effective, but the incentive effect is not as good as the incentive to be a positive incentive (reward); Positive incentive (reward). Because of the organization of the employee error reporting behavior to reward or punishment which are the behavior and report the error message of a way of attention.

4.3 Behavioral Data the EEG Data Structure Joint Analysis

In the experimental group, the P300 amplitude of no excitation was significantly smaller than that of the negative excitation, while the P300 amplitude of no excitation and the amplitude of negative excitation did not differ significantly in the control group. According to the results of behavioral data analysis, we can see that self-determination of the task to bring a stronger intrinsic motivation. High incentive reward motivation in 2011 is found by Murayama. K. and stimulate the individual more intense sense of happiness. Moreover, the magnitude of the amplitude of the P300 component is related to how much attention is drawn to the feedback result and the amplitude of the P300 increases as the excitation mode becomes more interesting. Therefore, it can be concluded that the participant will have more attention to the

experiment with the option, and less attention will be paid to the control group experiment with less attention. So it can be said that the intrinsic motivation to improve, can enhance the external incentives to the impact of subjects.

5 Discussion on Incentive Countermeasures Based on Error Report

Positive incentives (incentives) are more effective than negative incentives (punishments) in motivating individuals to report error motivations for reporting errors. This is also the recent researchers to promote the reporting behavior of the error reward, that reward and punishment are a powerful incentive mechanism. This study provides a mechanism for rewarding more efficient physiological experimental data. The inherent motivation for error reporting is to increase the individual's self - determination power for error reporting and to increase the individual's intrinsic motivation for error reporting.

Therefore, this paper proposes to make some management recommendations as follow:

5.1 Build Voluntary Errors Reporting System

Improve the error reporting incentive mechanism can be strengthened from two aspects of the staff will report the error. In increasing the motivation of employee error reporting, it is more effective to reward the error reporting behavior than punish the error concealment. Separate incentives for employees reporting errors can lead to more employees joining the ranks of reporting errors. The organization's reporting of errors to employees, whether rewarding or penalizing employees for errors, is an acknowledgment of error messages reported by employees, and this emphasis can also lead to employee risk of error But it is more effective to reward error reporting behavior, because the organization's attitude towards error reporting can lead to errors in the employee's sense of error. More attention to the occurrence of the error itself, rather than the first thought of this error will not bring me losses, to give employees a relatively open environment, can make everyone more willing to exchange error information; Reward can also increase the individual's Expected benefits, when employees believe that reporting errors have substantial benefits, tend to report the error [30], this change by changing the behavior of the employee's error reporting behavior is feasible.

According to the results of this paper, we can put forward some points needing attention:

1. Voluntary principles of error reporting.

According to the research conclusion, giving employees the right to self-determination of error incident reports can help to improve the intrinsic motivation of employee's error reporting behavior. Error reporting system is also designed to enable enterprises to get more comprehensive and accurate error information, voluntary

reporting model will enable enterprises to collect less of the useless information, greatly reducing the error information processing efficiency. But even so, companies cannot guarantee timely and effective collection of all the information, after all, reporting behavior is voluntary, you can report or not report. Therefore, another incentive mechanism is proposed.

2. Embedded in a reasonable incentive mechanism into the error reporting system.

According to the results of the study, when the individual in the report of the error, the more hope to see the incentive incentives, so employees can complete an error reporting task after its reward. But this reward is the need to control; otherwise it will only violate our intention to set up the error reporting system. Therefore, we can use the error reporting integral system to determine the extent of reward or punishment.

For example, when you report your errors in the Voluntary Reporting System, your reports are scored against your report's importance, validity, completeness, and operability, Points, the more points, the more bonuses; the same time, the system will make mistakes based on the size of the impact of your business to deduct the response points, but you can submit information to contribute to offset the knowledge, which is equivalent to Your information is valuable, then you add the score will be greater than the deduction to the score. In addition, the error event duplication of information, if there is no new educational significance, no extra points.

3. The availability of error reporting system.

When the voluntary principles and incentives are completed, the error reporting system must be established to consider its availability. Too complex, difficult to understand the system will reduce the enthusiasm of the staff error report: Imagine, when we finally determined to upload their experience, they encountered a system of how the uncertain, only our excitement poured Off, and then later do not want to use this system, because the reporting behavior is voluntary. At the same time, building an error reporting system requires enterprises to have the infrastructure with the performance matching to reduce the probability of system problems. Therefore, improving the availability of error reporting systems is also a way to keep employees reporting errors.

5.2 Interpreters Establish a Positive Error Management Atmosphere

A positive error management atmosphere is "the freedom of the organization to discuss errors, share knowledge of the error, but also in the face of error problems when dealing with and solve" [31]. Van Dyck C believes that the error management culture (EMC), like corporate safety culture, is also an important component of organizational culture, and the establishment of error management culture encourages employees to discuss their own mistakes without the burden of experience, All have a positive impact on the establishment of organizational error reporting systems [32].

Gold et al. (2014) also found that an open error management environment facilitates error reporting [33]. On the domestic front, Qunyang Xie et al. (2015) argue that a positive culture of error management will enhance employee willingness to report errors [32].

From a practical point of view, organizations often influence the behavior of employees through culture. At present, the transmission of error messages relies more on the degree of freedom that the organization provides to employees. Positive errors in the atmosphere, the higher the degree of freedom of employees for error reporting behavior of the intrinsic motivation is also higher. Creating a positive error management environment can be done in the following ways:

1. To build up establishment of easy discussion of errors and experience of the business environment.

Obstacles to employee error reporting behavior of the reasons, more because of their own psychological barriers, such as fear of being detained because of mistakes wages, fear of losing face is not easy to open, which is now the enterprise rules and regulations. Now the enterprise to establish a positive atmosphere of error management less, the rules and regulations is relatively harsh, so that individual employees are more willing to share their own error messages. But if everyone is hiding, then the same mistakes will continue to occur, so companies need to allow employees the freedom to explore the communication of an error event in the event of the problem, timely communication with others or errors Information can be reported, then the error event can be processed in time to prevent its continued deterioration; the same time can also reduce the recurrence of the same error event probability, in order to reduce the occurrence of security incidents. At this time a good organizational atmosphere will help improve the staff's willingness to report the error.

2. To carry out error culture training lectures.

Through the training of error culture, it can guide the employee's attribution of errors. This way not only to employees to express the importance of error events, as well as the degree of tolerance, but also to promote employees from a variety of aspects to study the causes of errors from the staring at the consequences of errors can be studied more Methods to solve this problem; on the other hand, it can also promote the innovation behavior of enterprise employees.

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