26. An Experimental Study of Human Factors in Software Reliability Based on a Quality Engineering Approach

In this chapter, we focus on a software design-review process which is more effective than other processes for the elimination and prevention of software faults in software development. Then, we adopt a quality engineering approach to analyze the relationships among the quality of the design-review activities, i.e., software reliability, and human factors to clarify the fault-introduction process in the design-review process.

We conduct a design-review experiment with graduate and undergraduate students as subjects. First, we discuss human factors categorized as predispositions and inducers in the design-review process, and set up controllable human factors in the design-review experiment. In particular, we lay out the human factors on an orthogonal array based on the method of design of experiments. Second, in order to select human factors that affect the quality of the design review, we perform a software design-review experiment reflecting an actual design process based on the method of design of experiments. To analyze the experimental results, we adopt a quality engineering approach, i.e., the Taguchi method. That is, applying the orthogonal array $L_{18}(2^1 \times 3^7)$ to the human-factor experiment, we carry out an analysis of variance by using the signal-to-noise ratio (SNR), which can evaluate the stability of the quality characteristics, discuss effective human factors, and obtain the optimal levels for the selected predispositions and inducers.

Further, classifying the faults detected by design-review work into descriptive-design and symbolic-design faults, we discuss the relationships among them in more detail.

Software faults introduced by human errors in development activities of complicated and diverse software systems have resulted in many system failures in modern computer systems. Since these faults are related to the mutual relations among human factors in such software development projects, it is difficult to prevent such software failures beforehand in software production control. Additionally, most of these faults are detected and corrected after software failure occurrences during the testing phase.

If we can make the mutual relations among human factors [26.1, 2] clear, then we expect the problem of software reliability improvement to be solved. So far, several studies have been carried out to investigate the relationships among software reliability and human factors by performing software development experiments and providing fundamental frameworks for understand-

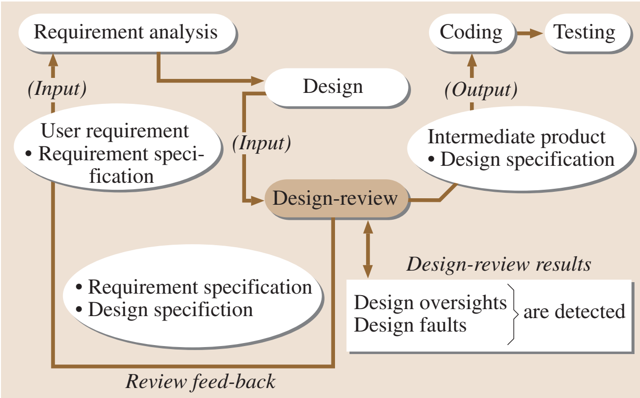

Fig. 26.1 Inputs and outputs in the software design process

ing the mutual relations among various human factors; see [26.3, 4].

In this chapter, we focus on a software design-review process that is more effective than other processes for the elimination and prevention of software faults. Then, we adopt a quality engineering approach [26.5, 6] to analyze the relationships among the quality of the design-review activities, i. e., software reliability, and human factors to clarify the fault-introduction process in the design-review process.

Furthermore, classifying the faults detected by the design-review work into descriptive-design and symbolical-design faults, we discuss the relationships among them.

26.1 Design Review and Human Factors

26.1.1 Design Review

The inputs and outputs for the design-review process are shown in Fig. 26.1 The design-review process is the intermediate process between the design and coding phases, and has software requirement specifications as inputs and software design specifications as outputs. In this process, software reliability is improved by detecting software faults effectively [26.7].

26.1.2 Human Factors

The attributes of the software designers and the design-process environment are related through the design-review process. Therefore, human factors that influence the design specification are classified into two kinds of attributes as follows [26.8–11] (Fig. 26.2):

1. Attributes of the design reviewers (predispositions)
   The attributes of the design reviewers are those of the software engineers who are responsible for the design-review work, for example, the degree of understanding of the requirement specifications and design methods, the aptitude of the programmers, their experience of and capability for software design, the volition of achievement of software design, etc. Most of these are psychological human factors which are considered to contribute directly to the quality of software design specification.
2. Attributes of the design-review environment (inducers)
   In terms of design-review work, many kinds of influential factors are considered, such as the learning level of design methods, the type of design methodologies, physical environmental factors for the software design work, e.g., temperature, humidity, noise, etc. All of these influential factors may indirectly affect the quality of the software design specification.

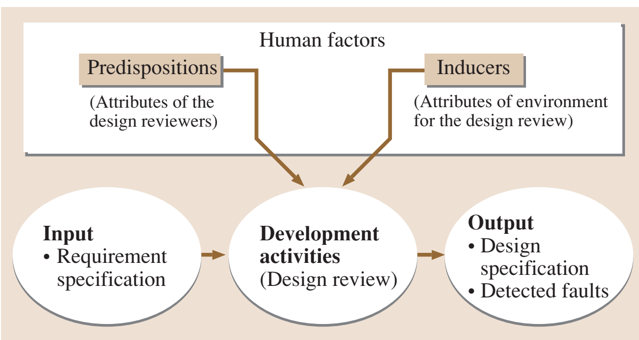

Fig. 26.2 A human-factor model including the predispositions and inducers

26.2 Design-Review Experiment

26.2.1 Human Factors in the Experiment

In order to discover the relationships between the reliability of the software design specification and the human factors that influence it, we have performed a design-review experiment by selecting five human factors, as shown in Table 26.1, as control factors concerned with the review work.

- BGM (background music) of classical music in the review-work environment (inducer A)
  Design-review work for detecting faults requires concentrated attentiveness. We adopt a BGM of classical music as a factor of the work environment that maintains review efficiency.
- Time duration of design-review work (inducer B)
  In this experiment, we set the subjects design-review work to be completed in approximately 20 min. We adopt three time durations for software design-review work, such as 20 min, 30 min and 40 min.
- Check list (inducer E)
  We prepare a check list (CL), which indicates the matters to be noticed in the review work. This factor has the following three levels: detailed CL, common CL, and without CL.
- Degree of understanding of the design method (predisposition C)
  Predisposition C of the two predispositions is the degree of understanding of the design method R-Net (requirements network). Based on preliminary tests of the ability to understand the R-Net technique, the subjects are divided into the following three groups: high, common, and low ability.
- Degree of understanding of the requirement specification (predisposition D)
  Predisposition D of the two predispositions is the degree of understanding of the requirement specification. Similarly to predisposition C, based on preliminary tests of geometry ability, the subjects are divided into the following three groups: high, common, and low ability.

26.2.2 Summary of Experiment

In this experiment, we conduct an experiment to clarify the relationships among human factors affecting software reliability and the reliability of design-review work by assuming a human-factor model consisting of predispositions and inducers, as shown in Fig. 26.2. The actual experiment has been performed by 18 subjects based on the same design specification of a triangle program which receives three integers representing the sides of a triangle and classifies the kind of triangle that these sides form [26.12]. We measured the capability of the 18 subjects in terms of their degree of understanding of the design method and the requirement specification by using preliminary tests before the design of experiment. Furthermore, we seeded some faults in the design specification intentionally. We then executed this design-review experiment in which the 18 subjects detected the seeded faults.

We performed the experiment using the five control factors with three levels, as shown in Table 26.1, which are assigned to the orthogonal array $L_{18}(2^1 \times 3^7)$ of the design of experiment, as shown in Table 26.3.

Table 26.1 Controllable factors in the design-review experiment

	Control factor	Level		
		1	2	3
A	BGM of classical music to review-work environment (inducer)	A_1: yes	A_2: no	–
B	Time duration of design-review work (minute) (inducer)	B_1: 20 min	B_2: 30 min	B_3: 40 min
C	Degree of understanding of the design method (R-Net technique) (predisposition)	C_1: high	C_2: common	C_3: low
D	Degree of understanding of the requirement specification (predisposition)	D_1: high	D_2: common	D_3: low
E	Check list (indicating the matters that require attention in the review work) (inducer)	E_1: detailed	E_2: common	E_3: nothing

26.3 Analysis of Experimental Results

26.3.1 Definition of SNR

We define the efficiency of the design review, i. e., the reliability, as the degree that the design reviewers can accurately detect correct and incorrect design parts for a design specification containing seeded faults. There exists the following relationship among the total number of design parts, n, the number of correct design parts, n_0, and the number of incorrect design parts containing seeded faults, n_1:

$$n = n_0 + n_1 . \tag{26.1}$$

Therefore, the design parts are classified as shown in Table 26.2 by using the following notation:

n_{00} = the number of correct design parts detected accurately as correct design parts,
n_{01} = the number of correct design parts detected by mistake as incorrect design parts,
n_{10} = the number of incorrect design parts detected by mistake as correct design parts,
n_{11} = the number of incorrect design parts detected accurately as incorrect design parts,

Table 26.2 Input and output tables for the two kinds of error

(i) Observed values			
Output / Input	0 (true)	1 (false)	Total
0 (true)	n_{00}	n_{01}	n_0
1 (false)	n_{10}	n_{11}	n_1
Total	r_0	r_1	n

(ii) Error rates			
Output / Input	0 (true)	1 (false)	Total
0 (true)	$1-p$	p	1
1 (false)	q	$1-q$	1
Total	$1-p+q$	$1-q+p$	2

where the two kinds of error rate are defined by

$$p = \frac{n_{01}}{n_0} , \tag{26.2}$$

$$q = \frac{n_{10}}{n_1} . \tag{26.3}$$

Table 26.3 Controllable factors in the design-review experiment

Experiment	Control factors								Observed values				SNR (dB)
						Error							
No.	*A*	*B*	*C*	*D*	*E*	*e*	*e*	*e*	n_{00}	n_{01}	n_{10}	n_{11}	
1	1	1	1	1	1	1	1	1	110	1	2	16	8.404
2	1	1	2	2	2	2	2	2	108	3	10	8	−0.515
3	1	1	3	3	3	3	3	3	109	2	16	2	−6.050
4	1	2	1	1	2	2	3	3	111	0	2	16	10.008
5	1	2	2	2	3	3	1	1	107	4	4	14	2.889
6	1	2	3	3	1	1	2	2	104	7	11	7	−4.559
7	1	3	1	2	1	3	2	3	111	0	4	14	8.104
8	1	3	2	3	2	1	3	1	106	5	8	10	−0.780
9	1	3	3	1	3	2	1	2	110	1	11	7	2.099
10	2	1	1	3	3	2	2	1	110	1	11	7	2.099
11	2	1	2	1	1	3	3	2	106	5	4	14	2.260
12	2	1	3	2	2	1	1	3	105	6	12	6	−4.894
13	2	2	1	2	3	1	3	2	105	6	10	8	−2.991
14	2	2	2	3	1	2	1	3	108	3	15	3	−5.784
15	2	2	3	1	2	3	2	1	105	6	10	8	−2.991
16	2	3	1	3	2	3	1	2	109	2	2	16	6.751
17	2	3	2	1	3	1	2	3	107	4	4	14	2.889
18	2	3	3	2	1	2	3	1	103	8	9	9	−3.309

Considering the two kinds of error rate, p and q, we can derive the standard error rate, p_0 [26.6] as

$$p_0 = \frac{1}{1 + \sqrt{\left(\frac{1}{p} - 1\right)\left(\frac{1}{q} - 1\right)}} . \quad (26.4)$$

Then, the signal-to-noise ratio based on (26.4) is defined by [26.6]

$$\eta_0 = -10 \log_{10} \left(\frac{1}{(1 - 2p_0)^2} - 1 \right) . \quad (26.5)$$

The standard error rate, p_0, can be obtained from transforming (26.5) by using the signal-to-noise ratio of each control factor as

$$p_0 = \frac{1}{2} \left(1 - \frac{1}{\sqrt{10^{\left(-\frac{\eta_0}{10}\right)} + 1}} \right) . \quad (26.6)$$

26.3.2 Orthogonal Array $L_{18}(2^1 \times 3^7)$

The method of experimental design based on orthogonal arrays is a special one that requires only a small number of experimental trials to help discover the main factor effects. In traditional research [26.4, 8], the design of experiment has been conducted by using the orthogonal array $L_{12}(2^{11})$. However, since the orthogonal array $L_{12}(2^{11})$ is applied for grasping the factor effect between two levels the human factors experiment, the middle effect between two levels cannot be measured. Thus, in order to measure it, we adopt the orthogonal array $L_{18}(2^1 \times 3^7)$, which can lay out one factor with two levels (1, 2) and seven factors with three levels (1, 2, 3), as shown in Table 26.3, and dispense with $2^1 \times 3^7$ trials by executing 18 experimentally independent experimental trials each other. For example, as for experimental trial no. 10, we executed the design-review work under the conditions A_2, B_1, C_1, D_3, and E_3, and obtained a computed SNR of 2.099 dB from the observed values $n_{00} = 110$, $n_{01} = 1$, $n_{10} = 11$, and $n_{11} = 7$.

Additionally, the interaction between two factors can be estimated without sacrificing a factor. Any pair of human factors are partially mixed with the effect of the remaining factors. Therefore, we have evaluated the large effects of highly reproducible human factors because the selected optimal levels of the relatively large factor has a larger effect than that of the smaller one.

Considering these circumstances, we can obtain the optimal levels for the selected inhibitors and inducers efficiently by using the orthogonal array $L_{18}(2^1 \times 3^7)$.

26.4 Investigation of the Analysis Results

26.4.1 Experimental Results

The experimental results for the observed values of the design parts discussed in Sect. 26.3.1 in the software design specification are shown in Table 26.3. The SNR data calculated using (26.5) are also shown in Table 26.3.

26.4.2 Analysis of Variance

The result of the analysis of variance for the observed correct and incorrect design parts is shown in Table 26.4 by using the SNR data, as shown in Table 26.3. In Table 26.4, f, S, V, F_0, and ρ represent the degree of freedom, the sum of squares, the unbiased variance, the unbiased variance ratio, and the contribution ratio, respectively, for performing the analysis of variance. In order to obtain the precise analysis results, the check list factor (factor E) is pooled with the error factor (factor e). We then performed the analysis of variance based on the new pooled error factor (factor e').

26.4.3 Discussion

As a result of the experimental analysis, the effective control factors such as the BGM of classical music to review-work environment (factor A), the duration of the design-review work (factor B), the degree of understanding of the software design method (Factor C), and the degree of understanding of the requirement specification (factor D) were recognized. In particular, factors A and B are mutually interacting.

We then find that our experience from actual software development [26.8] and the experimental result above based on a design review are equivalent. Table 26.5 shows the comparisons of SNRs and standard error rates. The improvement ratio of the reliability of design review is calculated as 20.909 dB [i. e. 33.1% measured in the standard error rate in (26.4) from (26.5)] by using the SNR based on the optimal condition (A_1, B_3, C_1, D_1) of the control factors, such as A, B, C, and D, whose effects are rec-

Table 26.4 The result of analysis of variance using the SNR

Factor	*f*	*S*	*V*	F_0	ρ (%)
A	1	36.324	36.324	10.578*	7.4
B	2	33.286	16.643	4.847*	5.9
C	2	229.230	114.615	33.377**	49.8
D	2	86.957	43.479	12.661**	17.9
E	2	3.760	1.880○		
$A \times B$	2	33.570	16.785	4.888*	6.0
e	6	23.710	3.952○	–	
e'	8	27.470	3.434	–	13.0
T	17	446.837	–	–	100.0

○: pooled, *: 5% level of significance,
**: 1% level of significance

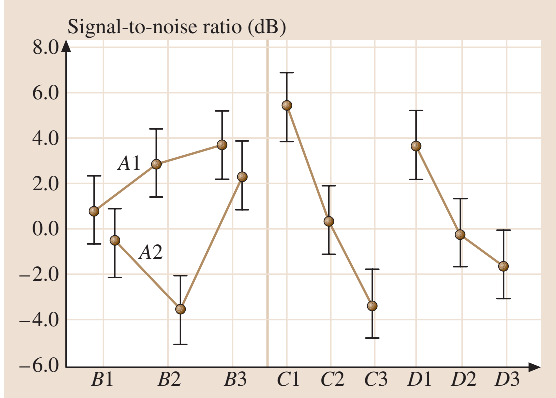

Fig. 26.3 Estimation of significant factors

ognized in Fig. 26.3. Therefore, it is expected that a quantitative improvement in the reliability of design review can be achieved by using these control factors.

26.5 Confirmation of Experimental Results

Table 26.6 shows the optimal and worst levels of the control factors for the design-review discussed in Sect. 26.4. Considering the circumstances, we conduct an additional experiment to confirm the experimental results using the SNR.

26.5.1 Additional Experiment

We focus on the effect of faults detected under the optimal conditions of the design-review work. As for the design of experiment discussed in Sect. 26.2, the design specification is for the triangle program reviewed by 18 subjects. We measured both their degree of understanding of the design method and their degree of understanding of the requirement specification by preliminary tests before the design of the additional experiment.

We also seeded some faults into the design specification intentionally. We then executed the same design-review experiment discussed in Sect. 26.2.2 under the same review conditions (the optimal levels for the selected predispositions). Additionally, we confirmed that the selected predispositions divided by the preliminary tests were consistent with the optimal levels of the two inducers.

The experimental results for the observed values of correct and incorrect design parts and the preliminary tests are shown in Table 26.7 with the SNR data calculated using (26.5).

26.5.2 Comparison of Factorial Effects Under Optimal Inducer Conditions

Figure 26.4 shows the optimal levels of the control factors of the design review based on the additional experiment. If both inhibitors are at the high state, the fault-detection rate is improved. Additionally, Table 26.8 shows a comparison of the SNRs and standard error rates between the optimal levels for the selected inducers. The improvement ratio of the reliability of the design review

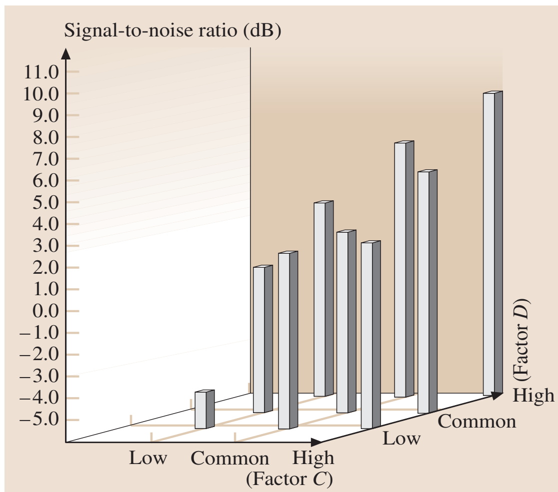

Fig. 26.4 The comparison of factorial effects

Table 26.5 The comparison of SNR and standard error rates

	Optimal conditions (A_1, B_3, C_1, D_1)	Worst conditions (A_2, B_2, C_3, D_3)	Deviation
Signal-to-noise ratio (dB)	10.801	−10.108	Δ 20.909
Confidence interval	±3.186		
Standard error rates (%)	2.0	35.1	Δ 33.1

Table 26.6 The optimal and worst levels of design review

	Control factor	Level	
		Optimal	Worst
Inducer A	BGM of classical music to review-work environment	A_1: yes	A_2: no
Inducer B	Time duration of design-review work (minute)	B_3: 40 min	B_2: 30 min
Predisposition C	Degree of understanding of the design method (R-Net technique)	C_1: high	C_3: low
Predisposition D	Degree of understanding of the requirement specification	D_1: high	D_3: low

Table 26.7 The SNRs in the optimal levels for the selected inducers

No.	Observed values				SNR	Standard	Observed values	
	n_{00}	n_{01}	n_{10}	n_{11}	(dB)	error rates	Factor C	Factor D
1	109	2	3	15	5.613	0.027	High	Common
2	111	0	5	13	7.460	0.040	Common	High
3	108	3	2	16	3.943	0.078	High	Low
4	107	4	4	14	2.889	0.094	High	Low
5	111	0	2	16	10.008	0.023	High	High
6	109	2	3	15	5.613	0.057	Low	High
7	107	4	4	14	2.889	0.094	Common	Low
8	107	4	4	14	2.889	0.094	Low	Common
9	111	0	2	16	10.008	0.023	High	High
10	109	2	4	14	4.729	0.068	Low	High
11	107	4	3	15	3.825	0.080	Common	Common
12	107	4	6	12	1.344	0.120	Low	Common
13	101	10	8	10	−3.385	0.220	Low	Low
14	105	6	3	15	2.707	0.097	Common	Low
15	107	4	3	16	3.825	0.080	Common	Common
16	111	0	4	14	8.104	0.035	Common	High
17	111	0	5	13	7.460	0.040	High	Common
18	98	13	9	9	−3.369	0.025	Low	Low

Table 26.8 The comparison of SNRs and standard error rates between the optimal levels for the selected inducers

	Factor C and factor D		Deviation
	High	Low	
Signal-to-noise ratio (dB)	10.008	−3.510	Δ 13.518
Standard error rates (%)	2.3	22.3	Δ 20.0

is calculated as 13.518 dB (i. e. 20.0% measured in the standard error rate) by using the signal-to-noise ratio based on the optimal conditions of the control factors, such as A, B, C, and D, whose effects are recognized in Fig. 26.4. Thus, we can confirm that the optimal levels of the two inducers are consistent with the optimal levels of the two predispositions C and D divided by the preliminary tests.

26.6 Data Analysis with Classification of Detected Faults

26.6.1 Classification of Detected Faults

We can distinguish the design parts as follows to be pointed out in the design review as detected faults into descriptive-design and symbolical-design parts, denoted by R_1 and R_2, respectively.

- Descriptive-design faults
  The descriptive-design parts consist of words or technical terminologies which are described in the design specification to realize the required functions. In this experiment, the descriptive design faults are algorithmic, and we can improve the quality of the design specification by detecting and correcting them.
- Symbolical-design faults
  The symbolical-design parts consist of marks or symbols which are described in the design specification. In this experiment, the symbolical-design faults are notation mistakes, and the quality of the design specification cannot be improved by detecting and correcting them.

26.6.2 Data Analysis

The experimental results for the observed values classified into the two types of design parts discussed in Sect. 26.6.1 are shown in Table 26.9. The SNR data calculated through (26.5) are also shown in Table 26.9.

A result of the analysis of variance for the descriptive-design parts is shown in Table 26.10, and that for the symbolical-design parts shown in Table 26.11, based on the SNR data shown in Table 26.9. Figure 26.5 shows the effect for each level in the control factor that affects the design-review result based on the SNR calculated from the observation values.

Descriptive-Design Faults

In design-review work, the effective review conditions for correcting and removing algorithmic faults are BGM of classical music, "yes(A_1)" and design-review time, "40 minutes(B_3)". The reviewer's capability, the degree of understanding of the design method (R-Net Technique), "high(C_1)", and that of the require-

Table 26.9 The orthogonal array $L_{18}(2^1 \times 3^7)$ with assigned human factors and experimental data

No.	Control factor					Observed values								SNR (db)	
						Descriptive-design parts R_1				Symbolic-design parts R_2					
	A	B	C	D	E	n_{00}	n_{01}	n_{10}	n_{11}	n_{00}	n_{01}	n_{10}	n_{11}	R_1	R_2
1	1	1	1	1	1	52	0	2	12	58	1	0	4	7.578	6.580
2	1	1	2	2	2	49	3	8	6	59	0	2	2	−3.502	3.478
3	1	1	3	3	3	50	2	12	2	59	0	4	0	−8.769	−2.342
4	1	2	1	1	2	52	0	2	12	59	0	0	4	7.578	8.237
5	1	2	2	2	3	50	2	4	10	57	2	0	4	1.784	4.841
6	1	2	3	3	1	45	7	8	6	59	0	3	1	−7.883	0.419
7	1	3	1	2	1	52	0	2	12	59	0	2	2	7.578	3.478
8	1	3	2	3	2	47	5	6	8	59	0	2	2	−3.413	3.478
9	1	3	3	1	3	52	0	10	4	58	1	1	3	0.583	4.497
10	2	1	1	3	3	52	0	10	4	58	1	1	3	0.583	4.497
11	2	1	2	1	1	47	5	1	13	59	0	3	1	3.591	0.419
12	2	1	3	2	2	46	6	8	6	59	0	4	0	−6.909	−2.342
13	2	2	1	2	3	46	6	10	4	59	0	0	4	−10.939	8.237
14	2	2	2	3	1	49	3	11	3	59	0	4	0	−8.354	−2.342
15	2	2	3	1	2	46	6	10	4	59	0	0	4	−10.939	8.237
16	2	3	1	3	2	50	2	2	12	59	0	0	4	4.120	8.237
17	2	3	2	1	3	50	2	4	10	57	2	0	4	1.784	4.841
18	2	3	3	2	1	44	8	6	8	59	0	3	1	−5.697	0.419

Table 26.10 The result of analysis of variance (descriptive-design faults)

Factor	f	S	V	F_0	ρ (%)
A	1	65.338	65.338	7.915*	8.071
B	2	96.907	48.454	5.869*	11.367
C	2	263.701	131.851	15.972**	34.950
D	2	108.953	54.477	6.599*	13.070
E	2	13.342	6.671○		
$A \times B$	2	106.336	53.168	6.053*	12.700
e	6	52.699	8.783○	–	
e'	8	66.041	8.255	–	19.842
T	17	707.276	–	–	100.0

○: pooled, *: 5% level of significance,
**: 1% level of significance

ment specification, "high(D_1)", are derived as optimal conditions.

Symbolic-Design Faults

In design-review work, the optimal condition for effective review conditions for correcting and removing notation mistakes is that the degree of understanding of the requirement specification is "high(C_1)".

26.6.3 Data Analysis with Correlation Among Inside and Outside Factors

Furthermore, classifying the detected faults as due to the outside factor R and the inside control factors A, B, C, D, and E, as shown in Table 26.9, we can perform the analysis of variance. Here, the outside factor R has two

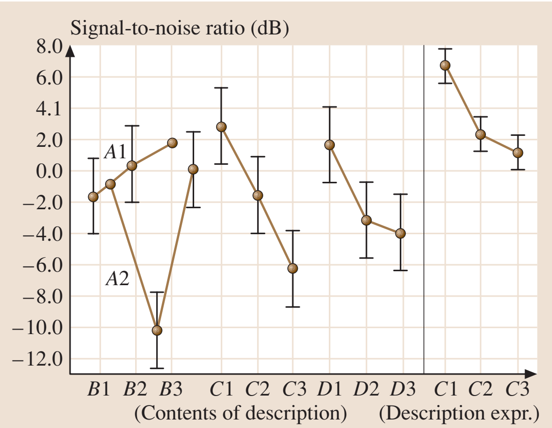

Fig. 26.5 The estimation of significant factors with classification of detected faults

Table 26.11 The result of analysis of variance (symbolic-design faults)

Factor	f	S	V	F_0	ρ (%)
A	1	0.037	0.037○		
B	2	29.041	14.521	2.975	8.180
C	2	86.640	43.320	8.875**	32.618
D	2	38.300	43.320	3.923	12.108
E	2	37.783	18.892	3.870	11.889
$A \times B$	2	4.833	2.416○		
e	6	38.759	6.460○	–	
e'	9	43.929	4.881	–	35.206
T	17	235.693	–	–	100.0

○: pooled, *: 5% level of significance,
**: 1% level of significance

Table 26.12 The result of analysis of variance by taking account of correlation among inside and outside factors

Factor	f	S	V	F_0	ρ (%)
A	1	37.530	37.530	2.497	3.157
B	2	47.500	23.750	1.580	3.995
C	2	313.631	156.816	10.435**	26.380
D	2	137.727	68.864	4.582*	11.584
E	2	4.684	2.342	0.156	0.394
$A \times B$	2	44.311	22.155	1.474	3.727
e_1	6	38.094	6.460	0.422	3.204
R	1	245.941	16.366	16.366**	20.686
$A \times R$	1	28.145	28.145	1.873	2.367
$B \times R$	2	78.447	39.224	2.610	6.598
$C \times R$	2	36.710	18.355	1.221	3.088
$D \times R$	2	9.525	4.763	0.317	0.801
$E \times R$	2	46.441	23.221	1.545	3.906
e_2	8	120.222	15.028	3.870	10.112
T	35	1188.909			100.0

*: 5% level of significance, **: 1% level of significance

levels, corresponding to descriptive-design parts (R_1) and symbolical-design parts (R_2).

As a result of the analysis of variance, by taking account of correlation among inside and outside factors, we can obtain Table 26.12. There are two kinds of errors in the analysis of variance: e_1 is the error among the experiments of the inside factors, and e_2 is the mutual correlation error between e_1 and the outside factor. In this analysis, since there was no significant effect by performing F-testing for e_1 with e_2, F-testing for all factors was performed using e_2. As a result, the significant control factors, such as the degree of understanding of the

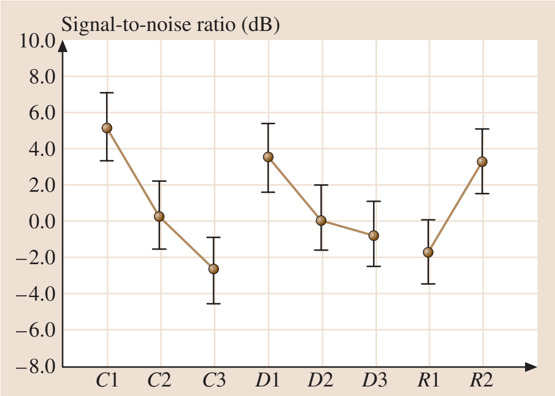

Fig. 26.6 The estimation of significant factors with correlation among inside and outside factors

design method (factor C), the degree of understanding of the requirement specification (factor D), and the classification of the detected faults (factor R), were recognized. Figure 26.6 shows the effect of the factor for each level in the significant factors that affect the design-review work.

As a result of the analysis, in the inside factors, only factors C and D are significant and the inside and outside factors are not mutually interacting. That is, it turns out that the reviewers with a high degree of understanding of the design method and a high degree of understanding of the requirement specification can review the design specification efficiently regardless of the classification of the detected faults. Moreover, the result that the outside factor R is highly significant, i. e., the descriptive-design faults are detected less effectively than the symbolic-design faults, can be obtained. That is, although it is a natural result, it is difficult to detect and correct the algorithmic faults which would lead to an improvement in quality rather than the notation mistakes. However, it is important to detect and correct the algorithmic faults as this is an essential problem for quality improvement in design-review work. Therefore, in order to increase the rate of detection and correction of algorithmic faults, which would lead to quality improvement, before design-review work it is necessary to make reviewers understand fully the design technique used to describe the design specification and the contents of the requirement specifications.

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