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Human Error Management Paying Emphasis on Decision Making and Social Intelligence -Beyond the Framework of Man-Machine Interface Design-

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Abstract— **How latent error or violation induces a serious accident has been reviewed and a proper addressing measure of this has been proposed in the framework of decision making, emotional intelligence (EI) and social intelligence (SI) of organization and its members. It has been clarified that EI and SI play an important role in decision making. Violations frequently occur all over the world, although we definitely understand that we should not commit violations, and a secret to prevent this might exist in the enhancement of both social intelligence and reliability. The construction of social structure or system that supports organizational efforts to enhance both social intelligence and reliability would be essential. Traditional safety education emphasizes that it is possible to change attitudes or mind toward safety by means of education. In spite of this, accidents or scandals frequently occur and never decrease. These problems must be approached on the basis of the full understanding of social intelligence and limited reasonability in decision making. Social dilemma (We do not necessarily cooperate in spite of understanding its importance, and we sometimes make decision not to select cooperative behavior. Non-cooperation gives rise to a desirable result for an individual. However, if all take non-cooperative actions, undesirable results are finally induced to all.) must be solved in some ways and the transition from relief (closed) society to global (reliability) society must be realized as a whole. New social system, where cooperative relation can be easily and reliably obtained, must be constructed to support such an approach and prevent violation-based accidents.**

1. Introduction

As a part of our daily activities, we make mistakes or commit errors. We cannot spend a day without committing errors. Swain and Guttman [1] defined a human error as an output of tolerance action, where the limits of tolerable performance are defined by the system. Reason [2] regarded a human error as a generic term to encompass all occasions where a planned sequence of mental or physical activity fails to achieve its intended outcome, and an error cannot be attributed to some chance level. Hollangel [3] defined an error as an action which fails to produce the expected result and/or gives rise to an unwanted consequence. Meister [4] interpreted a human error as follows: A failure of a common sequence of psychological functions such as stimulus, organism, and response that are basic to human behavior. When any element of such a sequence is broken (failure of perceived stimulus, misinterpretation of meaning of stimulus, do not know how to respond to stimulus, etc.), a perfect execution cannot be achieved.

No human action stands alone. It is a part of a sequential cognitive process. Therefore, a human error must be understood in the context of human information processing. It must be noted that every error does not necessarily lead to a critical accident or a scandal. The understanding of error property and preventing it from developing a crucial accident is a very important aspect of human error or safety engineering research.

First, the classification of human error is carried out to understand the property of human error referring to the published research results [5]-[10]. Second, the prevention strategies of human errors or accidents are described, and the limitation of strategies practiced until now will be discussed.

There are following prevention measures of human error:

(a)Proper design of man-machine system according to the principle “Fitting the task to the man”

(b)Proper management of fatigue, workload, and stress

(c)Safety education paying emphasis on emotion

(d)Enhancement of sensitivity to errors

The measure (b) should be managed properly, because it is possible that low arousal, high workload, or high stress leads to human errors such as drowsy operation of machines or vehicles. The measures (c) and (d) are intensively discussed in this paper, because the prevention of violations stemming from lack in (c) and (d) is regarded as an effective method to the reduction of accidents or scandals due to improper organizational or managerial strategies. On the basis of such discussion, the concept of human error management must be carried out not only within the framework of man-machine system but also in the framework of organizational design [11] and social intelligence [12]-[13].

As for the approach from the viewpoints of organizational design, Desai and Roberts [11] discussed the relationship between safety climate of organization and recent accidents, and concluded that recent accidents may be associated with safety climate score. The improvement of safety climate might be one promising measure to prevent accidents. On the other hand, there exist no effective measures that made an attempt to prevent accidents or human errors (especially, violation) from the viewpoints of social intelligence [12]-[13] and limited reasonability in human's decision making [14]-[15].

As shown in Section 2, the most critical human error is (intentional) violation. Different from other types of errors such as slip, lapse, and mistake which are committed without intention, the violation is committed intentionally. Although we know that the violation is not permitted, many wrongly underestimate the risk of violation and overestimate the benefit obtained by individuals or organizations. This is indicative of limited reasonability or cognitive bias of risk proposed by prospect theory [14]-[15]. Without proper understanding of limited reasonability, interaction between IQ and EI (emotional intelligence) (We believe that this is promoted by the function of social intelligence (SI)), and human's cognitive bias in decision making, we cannot prevent violation-based accidents or scandals. Therefore, the measures (c) and (d) above are intensively discussed in this paper. The main purpose of this paper is to approach the underlying mechanism of violation from multiple perspectives, and propose a model that can explain violations.

2. Classification of human errors and understanding its property

Reason [7] classified human error as violation, mistake, slip, and lapse. This taxonomy allows the attribution of a possible origin to an error and to locate it in one of the three stages of cognitive information processing, that is, conception (planning), storage of information, and execution of an action sequence. Violation is intentionally committed. Mistakes are due to wrong plan, where an action is executed according to the plan and the intention, but the plan is wrong. Lapses occur due to retention deficits. In this type of error, the intention is not retrieved or recalled on time or at all. Slips occur under the correct plan due to the wrong execution, because the action is not appropriate to the plan. It must be noted that we do not intentionally commit mistakes, lapses, and slips.

The type of errors mentioned above does not capture all the ways in which humans contributes to major accidents. An adequate framework for aberrant behaviors requires a distinction between errors and violations. Both can be present within the same action sequence, but they can occur independently. While one may make an error such as slips, lapses, and mistakes without committing a violation, a violation need not involve errors. Slips [16] and lapses correspond to the unwitting deviation of action from intention, and mistakes correspond to the departure of planned actions from a goal. These errors offer only a partial account of the possible varieties of aberrant behavior. For the most part, humans do not plan and execute their actions in isolation, but within regulated social environment. While error may be defined in relation to the cognitive processes of the individual, violations can only be described with regard to a social context in which behavior is governed by operating procedures, code of practice, rules and so on. Therefore, violations can be defined as intentional deviations from those practices deemed necessary to maintain the safe operation of a potentially hazardous system. What is certain is that dangerous aberrations cannot be prevented within the framework of either the cognitive or the social psychological approach. Both approaches must be integrated within a single framework.

There are some cases where violations do not have some degree of intentionality. The cases where one doesn't know the rule or doesn't have proper knowledge are examples of such a violation. When the risk is underestimated, it is possible that a violation is committed in order to obtain higher efficiency. According to Reason [7], violations can be classified into two types: routine violations and exceptional violations. Routine violations are related with the two habitual violations: (1) a natural human tendency to take the path of least effort, and (2)a relatively indifferent environment where, for example, violations are rarely punished. Exceptional violations are not so clearly specified. This type of violation

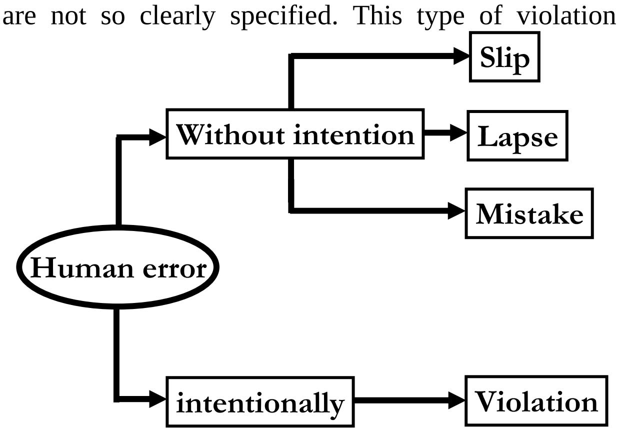

Figure 1. Taxonomy of human errors based on Reason [7].

Table 1. Taxonomy of human errors based on the cognitive stages.

Cognitive stage	Primary error type
Planning	Mistake
Storage	Lapse
Execution	Slip

Table 2. Taxonomy of human errors on the basis of the cognitive layer model.

Cognitive layer	Error type
Skill-based level	Slip and Lapse
Rule-based level	Rule-based mistake
Knowledge-based level	Knowledge-based mistake

seems to be related to tasks or operating circumstances that make violation inevitable. Different from the errors such as slips, lapses, and mistakes based on the cognitive science, the underlying mechanism of violations is not well documented. To carry out this (clarify the mechanism of violation), an interdisciplinary approach including social psychology, organizational design and psychology, social neuroscience, and cognitive science, especially humans' decision making process is essential. The taxonomy based on Reason [7] is summarized in Figure 1. In Table 1, the taxonomy of error is summarized according to the cognitive stages at which they occur.

Rasmussen [9]-[10] classified human error on the basis of cognitive layer model (skill-, rule-, and knowledge-based models) as follows: Knowledge-based mistakes, rule-based mistakes, and skill-based errors such as slips and lapses (See Table 2). When we interpret the three errors in the framework of cognitive stage, the knowledge-, rule-, and skill-based error corresponds to formulation of intention, planning of action, and storage of information, respectively. Norman [16] classified errors as follows: error in the formation of intention, error in activation of schemas, and error in triggering of active schemas, which corresponds to formation of intention, execution of action, and execution of action, respectively.

As shown in Figure 2, errors can also be classified as variable, constant, and sporadic errors. Each shows a pattern of shot by different riflemen. The pattern of variable errors exhibits no constant error, only a large amount of variable error. The pattern of constant errors shows the reverse: a large constant error, but small variable error. These two errors are predictable.

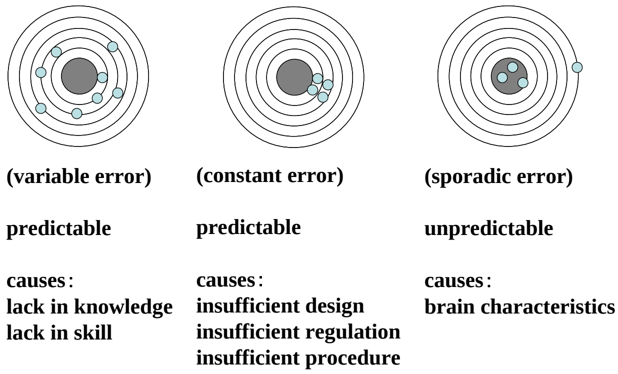

Figure 2. Variable, constant, and sporadic errors.

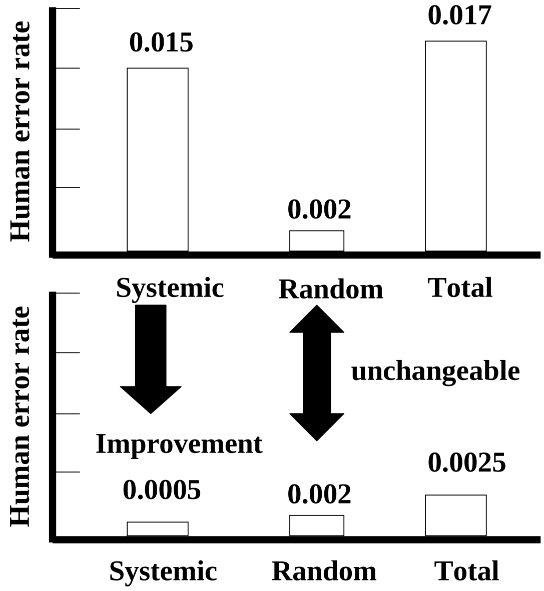

Figure 3.Systemic and random errors.

The lack in knowledge and skill is the main cause of constant error. The variable error occurs due to the insufficient design, regulation, and procedure. It is impossible to predict sporadic error. Suddenly, the shot is deviated from the center. This cause must due to the brain characteristic, such as overstressed state. In Figure 3, comparison of systemic and random errors after system improvements are shown. While the systemic error can be improved by means of a proper approach such as an ergonomic design, it must be noted that random error cannot be entirely eliminated.

Latent and active errors are also another classification of human errors. Active errors become immediately obvious at, or soon after, the time when the error is committed, especially when there is a close association between the task and the error. On the other hand, the consequence of a latent error is not immediate due to the inherent latency. When a latent error occurs, it is possible to complete the sequence of tasks without the error being revealed. In the case of an active error, the sequence of tasks cannot be completed. Such a nature of latent errors makes them more insidious than active errors. The latent errors occur during maintenance operations and in the context of management decision making. It is well known that may serious accidents have resulted from latent errors in maintenance activities such as aviation industry and nuclear power plant. An error gradually revealed without human identifying the error, and there existed many cases where this led to serious and crucial accidents. Most management errors are latent in their effects. Decision making errors are always latent and their effects can be delayed for extremely long periods of time before errors are detected, and it is possible that this leads to a crucial accident without the error being detected.

Using the explosion at the Nypro chemical works at Flixborough in 1974, the latent error is explained. When a split developed in one of the reactors, a decision was made by management to replace the reactor with a temporary 20 inch diameter bypass pipe connected to the adjoining reactors by expansion bellows and inadequately supported by temporal scaffolding. The arrangement was subsequently found to be vulnerable to unforeseen mechanical stress when operating at high pressure or subject to mechanical impact due to the propagation through the system of slug of liquid reactant. A failure of the bypass pipe 3 months after its installation eventually led to an immense aerial explosion which lost 28 lives and damaged the factory and surrounding villages.

This type error is strongly related to the violation arising inside the organization. The omission of maintenance duty, which corresponds to the violation in the maintenance task, leaves the latent error, and this error gradually degraded the system, revealed, and eventually led to a serious accident.

In this paper, how violations induce serious accidents has been discussed and a proper addressing measure to prevent this would be presented in the framework of limited reasonability in decision making and social intelligence of organization and its members.

3. Analysis of causes of human error or accident

3.1 Accident at Bhopal Union Carbide Corporation

On the night of 2-3, December, 1984, a gas leaked from a pesticide plant owned by a subsidiary of Union Carbide Corporation. This accident devastated Bhopal, and was the worst industrial disaster ever. About 3,800 people were killed, and more than 200,000 were injured. This revealed the largely unrealized danger associated with the manufacture of highly toxic chemicals (in this case, methyl isocyanate (MIC)).

The immediate cause of this accident was an influx of water into a MIC storage tank. How the accident occurred is a tangled combination of botched maintenance, operator error, improvised bypass pipes, failed safety system, incomplete management, drought, agricultural economics, and poor government decisions.

Management errors can be summarized as follows.

(1)Locating a high risk plant to a densely populated residential area.
(2)Poor emphasis on system safety (invest little money on safety).
(3)No improvement in safety measures despite six prior minor accidents.
(4)Storing 10 times more MIC than was needed daily.
(5)Poor evacuation measures.
(6)Neglect of factory inspector’s warning on washing MIC lines.
(7)Failure to release telex message on MIC treatment.

Human error (mainly failure in situation awareness due to lack in knowledge) strongly associated with management error can be listed as below.

(1)Heavy reliance on inexperienced operators and supervisors.
(2)Reduction in operating and maintenance staff due to management policy of cost reduction.
(3)Employing non-trained and inexperienced superintendents due to management policy of cost reduction.
(4)Re-pressuring the tank when it failed to get pressurized once.
(5)Issuing orders for washing when MIC tank failed to re-pressurize.
(6)Did not operate warning siren until leak became severe.
(7)Switching off siren immediately after starting it.
(8)Failure to recognize that pressure rise was abnormal.
(9)Failure to use empty MIC tank to release pressure.

Hardware error can be pointed out as follows.

(1)Insufficient scrubber capacity.
(2)No automatic sensors to warn of temperature increase.
(3)Manual mechanism for switching off scrubber.
(4)No online monitor for MIC tanks.
(5)No indicator for monitoring position of valves in control room.
(6)Refrigeration plant not operational.
(7)No operation of pressure and temperature indicators.
(8)Insufficient availability of gas masks.
(9)Disconnection of flare tower.
(10)Inactive mode of vent gas scrubber.
(11)Use of iron pipes for transporting MIC.

As mentioned, management (organizational) errors or violations, together with human errors and hardware (machine) errors, led to such a disaster.

3.2 NASA challenger accident

The cause of the Space Shuttle Challenger accident on the morning of 28 January, 1986 was the shortly split of rubbery seal called an O-ring. An O-ring on one of the solid rocket boosters split shortly after lift-off, releasing a jet of ignited fuel that caused the entire shuttle complex to explode. The related management errors can be summarized as follows.

In 1977, during the test firing of solid rocket booster, Thiokol engineers discovered that casing joints expanded. They persuaded NASA that this was not desirable but acceptable. They also found that one of the two O-ring joint seals frequently became unseated, thus failing to provide backup as firstly designed. In 1981, NASA planned two lightweight versions of the boosters (steel and carbon filament) in order to increase payload. Hercules submitted an improved design for the carbon filament), incorporating a lip at the joint to prevent the O-ring from unseating. In spite of this Thiokol continued to use unmodified joints for its steel boosters. Erosion was noticed on one of the six primary O-rings which was the same joint that was involved in the Challenger accident. In 1982, NASA upgraded the criticality rating on the joints to 1, meaning that the failure of this component lead to critical accident. Although some NASA engineers seek to adapt Hercules capture feature into the new thinner boosters in 1983, the proposal was shelved and the old joints continued to be used.

In 1984, just before the 10th launch of shuttle, high pressure air tests were carried out on the booster joints. An inch long scorch was found on one of the primary O-rings. Despite the above mentioned criticality 1 rating, Marshall Space Center reported that no remedial action was necessary. Moreover, on 11th launch, one of the primary O-rings was found to be breached altogether. In spite of this, no action was taken by NASA.

In 1985, breaches were found on four of the booster joints. Weather at launch was the coldest to date (51 deg F with 53 deg F at the joints). On the 17th launch, the primary O-ring in the nozzle joint failed to seal, and scorching was found all the way round the joint. NASA booster manager placed a launch constraint so that no launch can take place if there were any worries about a “criticality 1” item. Top NASA management was still unaware of this constraint. Thiokol engineer wrote a memo warning of catastrophe if a blowout should occur in a field joint. Marshall and Thiokol engineers met in Washington to discuss this problem. NASA management missed this meeting. This could not have been solved until the launch of Challenger. Unfortunately, on the night before the launch, the temperature fell into 20 deg F colder than the previous coldest launch a year earlier. At this point, Allan McDonald, Thiokol’s chief engineer at the Kennedy Space Center attempted to stop the launch.

The cause of this disastrous accident is a complicated combination of incompetence, selective blindness (groupthink (in detail, see 5.2), conflicting goals and reversed logic. The organizational (management) error hindered the stop of launch in spite of some engineer groups recognized the risk of launching without the deficiencies improved.

3.3 Chernobyl accident

The related management errors can be summarized as follows. At 13:00 on 25 April, 1986, power reduction started with the intention of achieving test conditions. The tests were planned to be carried out at 25% full power. In this event, organizational (managerial) error and violations are included. The test was to see whether the coast- down capacity of a turbine generator would be sufficient, given an appropriate voltage generator, to power the Emergency Core Cooling System (ECCS) for a few minutes. This would fill the time to get the diesel standby generator into operation. A voltage generator had been tested on two previous occasions, but had failed due to rapid voltage fall-off. The goal of the test was to carry out repeated checking prior to the annual maintenance shutdown to be scheduled in the near future. Authority to carry out the test was given to the staff without the approval of the Safety Technical Group. In addition, it was generally very dangerous to carry out such tests in RBMK type plants on safety grounds. Making matters worse, the staff (electrical engineers) had little knowledge on reactor plants.

At 14:00, the ECCS was disconnected from the primary circuit. This stripped the plant of one of its main defenses. Five minutes later, Kiev controller asked Unit4 to continue supplying grid. However, the ECCS was not reconnected. Although this failure did not contribute directly to the subsequent explosions, it was indicative of a lax attitude of operators towards the observance of safety procedures. Subsequent 9-hour operating at around 50% full power increased xenon poisoning, making the plant more difficult to control at low power. The design of RBMK reactor renders it liable to positive void coefficient at power setting below 20% full power. After a long struggle, reactor power was stabilized at 7% full power. At this point, the test should have been stopped in view of the very low power setting.

Having been released from the grid at 23:10, operators continued to reduce power. Operators omitted the order to hold power. This led to very low power. Operators continued to improvise in an unfamiliar and increasingly unstable regime to protect the test plan. The plant reached to super prompt critical, and eventually explosions occurred at 01:24.

The low safety climate behind which many managerial errors and the poor design of RBMK reactor existed strongly affected the occurrence of this disastrous accident.

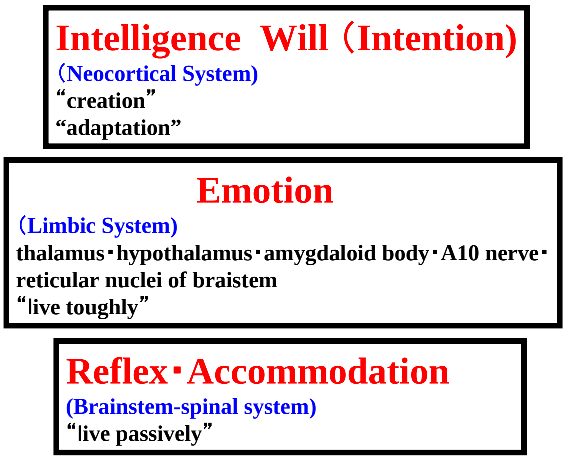

Figure 4. Classification of central nervous system into three systems.

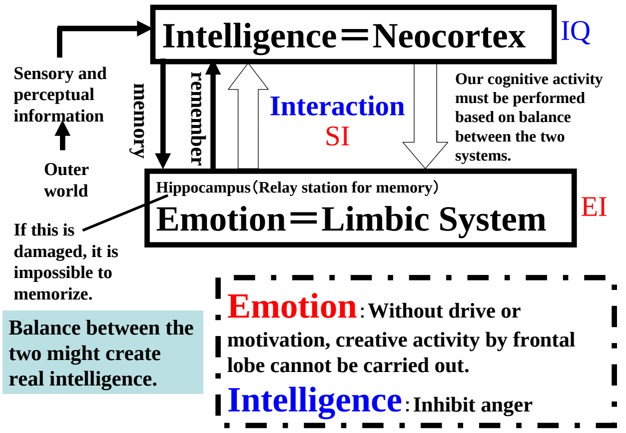

Figure 5. Interaction between neocortex (intelligence) and limbic system (emotion).

4. Proposal of new concept toward prevention of errors and accidents

4.1 Emotion and decision making

As shown in Figure 4, our brain can be classified into three systems, that is, neocortical, limbic, and brainstem-spinal systems. The neocortical and limbic systems act and work interactively as shown in Figure 5. Damasio [17] suggested that emotion plays an important role in decision making. Eliot was an excellent business person. A part of frontal lobe was removed due to the brain tumor. Although his health condition was improved after the operation of brain tumor, and his motor, language, and intellectual functions did not differ from that before the operation. The intelligent quotient (IQ) was also kept high, and there were no deficiencies in logical thinking, attentional level, and memory. His personality was as it was before the operation. However, it was impossible for Eliot to express his emotional feeling (did not inhibit his emotional feeling intentionally) and make decision. Based on such observations, Damasio [17] concluded that there might be close relationship between emotion and decision making.

Our judgment or decision is sometimes based on heuristics(availability, representativeness, anchoring and adjustment, etc.). There is evidence that emotion functions as heuristics. Zajonc[18] suggested that every perception is accompanied by some emotion. We frequently confront with selection problems in our daily life. We rarely judge reasonably by taking into account the advantages and the disadvantages of all alternatives, rather we intuitively evaluate emotional aspects such as “good”, “bad”, “comfortable” , or “uncomfortable” of alternatives, and make final decision. If the confronted selection problem is complicated, and there are less time and few cognitive resources to solve it, we conform to such a heuristic approach. In other words, it is reasonable to think that emotion functions as heuristics.

An example which demonstrates that emotion works as heuristics is mentioned. In general, there is a positive correlation between risk and benefit. The larger the benefit, the lager the risk is. The smaller the benefit, the smaller the risk is. However, this might be unacceptable. When we like the activity and it induces positive emotion, we tend to underestimate the risk and overestimate the benefit. By contraries, when we dislike the activity and it induces negative emotion, we tend to overestimate the risk and underestimate the benefit. Shiv and Fedorikin [19] showed the following experimental results. Participants were required to memorize 2- or 7-digit number and recall this at other room. When moving to other room, participants were required to select one of the two alternatives (chocolate cake or fruit salad). It tended that the group assigned to 7-digit number selected a chocolate cake, and the group assigned to 2-digit number selected a fruit salad. It must be noted that both groups recognized that fruit salad is better for their health. The group assigned to 2-digit memory task could judge calmly because there were enough cognitive resources left as compared with the group assigned to 7-digit memory task.

Emotion as a means of commitment is discussed. In the framework of commitment problem, we show that leaving decision making to emotion leads to a better result than thinking reasonably and making decision. Commitment means that incentive or expectation is changed by giving up one or a few alternatives. Commitment affects own behavior. In other words, abandoning a few alternatives and affecting own or others’ future behavior corresponds to commitment. Imagine that you have a bag of 20,000 yen, and your acquaintance is eager to have it. When your acquaintance steals your bag, you must make decision whether you bring a suit against him or her. When filing a suit, your cost including expenses for hiring a lawyer, and opportunity loss cost by taking a day off is more than 20,000 yen. In this case, there seems to be no economic merit. Assume that you tend to pursuit economic benefit. If you acquaintance knows this and judges that you will not bring a suit against him or her in spite of playing a losing game, he or she may steal your bag. Assume that you do not necessarily pursuit economic benefits. If your acquaintance knows that you surely bring a suit against him or her by playing a losing game, he or she will never steal your bag.

A similar example is demonstrated. Imagine further that you jointly run a restaurant. Your acquaintance is a professional of cooking, and you are accustomed to business administration. Both have a drive to deceive the partner. You have a drive to monopolize the benefit. Your partner also has a drive to a kickback from food suppliers. Either is tempted by the drive, and you or your partner can get larger profit. If both are tempted by the drive, the restaurant's business situation gets worse. If both are honest, the restaurant's business situation gets better. It is important to impress your partner that you will never forgive him or her (If your partner betrays you, you will be prepared to pursuit your partner by sacrificing to some extent). Such an image is implanted to your partner. Thus, unreasonable behavior which persists not in reasonability but in emotion leads to a better result.

Somatic marker hypothesis proposed by Damasio[17] assumes that a sort of "physical sensing" plays an important role in inference and decision making. The base of this hypothesis is that some events, things, or places give rise to some emotional feeling (either positive or negative). The event, thing, or place is stored into a memory system together with the emotion. When we encounter a similar experience, we feel similar comfort or discomfort. Damasio [17] simulated a gamble to verify the hypothesis. There were four stacks (A, B, C, D) each of which consisted of many cards. Virtual money of 2000$ was provided to each participant, and he or she was required to earn as much money as possible. Every time players turned the card, they got some money, or a penalty was imposed on them. The stacks A and B were very risky. Although the maximum profit per card was very high (100$), these stacks also included cards with higher penalty. Concerning the risky stacks A and B, profit per one card was 100$, but there were some cards with higher penalty. As for the safe stacks C and D, profit per one card was low and $50, and the penalty was also low. Expected profit of $25 was obtained. The players were not informed of this structure. Healthy group gradually noticed that A and B were risky, and sooner or later tended to select C and D. The function of somatic marker seems to enable them to intuitively sense that A and B are risky. Frontal robe damaged group adhered to risky stacks A and B, and eventually got bankrupted. As the somatic marker does not work, it might be impossible to sense the danger of stacks A and B.

Emotion, in general, tended to be avoided, and the following sentences represent this tendency: "Don't be emotional", "Judge calmly", and "Emotion is an obstacle to reasonable decision making." Recently, the important role of emotion in judgment or decision making has been recognized. It is impossible to judge or make decision properly without emotion (Damasio [17]). To obtain a perfectly theoretical framework on human's reasonable behavior, we need to clarify how emotion is related to judgment or decision making. Our judgment or decision is made on the basis of heuristics (anchoring and adjustment, availability, or representativeness). Emotion functions as heuristic, and is essential for reasonable judgment or decision making. For the proper risk assessment and the prevention of human error (violation), accident or scandal, it must be recognized that emotion plays an important role.

4.2 Groupthink

Groupthink is peculiar to highly coherent groups. In such groups, each member is strongly attracted to the group, mainly due to the attractiveness of a leader, and comfort within the group. Decision is distorted to a unreasonable direction, because an agreement within the group is consciously obtained. The properties of groupthink can be summarized as follows:

・Overevaluation of the group
・Press group's own moral to each member
・Indifferent reaction to the opinion of outsider
・Inspection to an opinion that is not mainstream
・Pressure requiring unanimity

As mentioned in Section 3.2, the engineering staff at T-company in advance pointed out the danger that O-ring might harden due to cold climate. If all concerned makers don't agree with the launching, the launching cannot be carried out (very strict system). However, T-company agreed with the launching. The launch of space shuttle should have been postponed. Unreasonable decision making by groupthink occurred during this process. As the launching had been postponed two times, the NASA staff was impatient about this. The top management of T-company had sufficiently understood such a circumstance. Only their company did not agree with the launching. The top management of T-company felt sorry for such a circumstance. Eventually they fell into groupthink, and agreed with the launching in spite of recognizing the danger or risk of launching.

4.3 CSR and compliance

We should not hide an error or scold subordinate who committed an error. We should regard an error as a valuable lesson and knowledge (fortune) for the progress of organization. We should behave so that an error would not lead to an accident or a scandal. An error must be conveyed to everyone (We should not forget an error). The organization with high resistance to errors or accidents, in which each member is educated so that he or she can be sensitive to errors or accidents, is vivid and active. Such an organization can attain high productivity (efficiency).

CSR (Corporate Social Responsibility) is a very important concept for preventing accidents or scandals. CSR includes the concept of compliance which means satisfaction of social request such as safety. Compliance plays an important role in the prevention of accidents or scandals which stems from violations. It is not until the organization satisfies social request that it is recognized by the society. When such an activity is not observed in organizations, a scandal is sure to occur. In active and vivid organizations, the top management understands the situation of each member. When accidents or scandals happen, the organization needs to identify the cause thoroughly, store this as knowledge data base, and carry out an effective measure to prevent this from occurring again. This corresponds to compliance. Society will not satisfy with an interview where top managements only apologize the accidents or scandals. The organization can evolve (become robust to accidents or scandals) by adapting to environment (sensitive response to social request). Not only top managements but also each organizational members must be sensitive to social request and responsibility so that violation can be avoided.

4.4 Emotional intelligence (EI) and social intelligence (SI)

To construct an organization with high resistance to errors or accidents, it is important and essential to raise staff with both emotional intelligence (EI) and social intelligence (SI). Such an organization must be robust to errors, accidents, and scandals. With only IQ, errors or accidents cannot be prevented. IQ is, of course, necessary for attaining high efficiency or producing usable products. In order to produce a good product which rarely induce an error, engineers must have SI and EI as well as IQ. Moreover, the balance between IQ and EQ or SI is important.

Emotional Intelligence includes the following abilities:

(a)Ability to recognize own emotion(self-recognition).

(b))Ability to control own emotion to a moderate state (self-control).

(c)Ability to enhance own feeling to attain own purpose (motivation).

These abilities are the basis for the construction of human relation, communication ability, and sensitivity to errors which are described below as social intelligence..

Social intelligence (SI) consists of social awareness and social facility [12]. Social awareness refers to sensing another's inner state to understand their feelings and thoughts, and includes the following aspects.

・Primal empathy: Feeling with others, and sensing non-verbal emotional signal.

・Attunement: Listening with full receptivity, and attuning to a person

・Empathy accuracy: Understanding other's thoughts, feelings, and intentions.

・Social cognition: Knowing how the social world works.

Social facility builds on social awareness to allow smooth and effective interactions, and includes the following aspects.

・Synchrony: Interacting smoothly at the nonverbal level.

・Self-presentation: Presenting ourselves effectively.

・Influence:Shaping the outcome of social interactions.

・Concern: Caring about others' needs and acting accordingly.

It is, of course, desirable that both IQ and EI are high, and the balance between the two is essential. This must lead to true intelligence, and it is proposed, in this paper, that social intelligence (SI) plays an important role to balance between IQ and EI and enhance reliability of organization or society.

One aspect of ability to balance between IQ and EI might be interpreted as follows.

(1)Recognize and understand own emotion

(2)Inhibition of emotion (become insensitive)

(3)Stress Management (self-control)

(4)Motivation

(5)Recognize and understand other's emotion

(6)Cope with human relation properly

The ability to balance between IQ and EI might be stated in another way as follows:

(A)Sensitive quotient (become sensitivity to errors)

(B)Insensitive quotient (become insensitive to rumors)

(C)Endurance quotient(ability to inhibit wicked mind)

(D)Decision ability (related to emotion (Damasio [17] pointed out that emotion plays an important role in decision making)

The concept of the balance between IQ and EI is summarized in Figure 6. It must be noted that EI and SI have not been so generally recognized as IQ, and the definition of such intelligence has not been systematically established. These concepts must be further elucidated and elaborated. Although further elaboration of these ideas is necessary, we believe that a secret to the reduction of violation lies in such a way of thinking and conceptualization. Next, it is discussed how SI would be helpful to the reduction of violations.

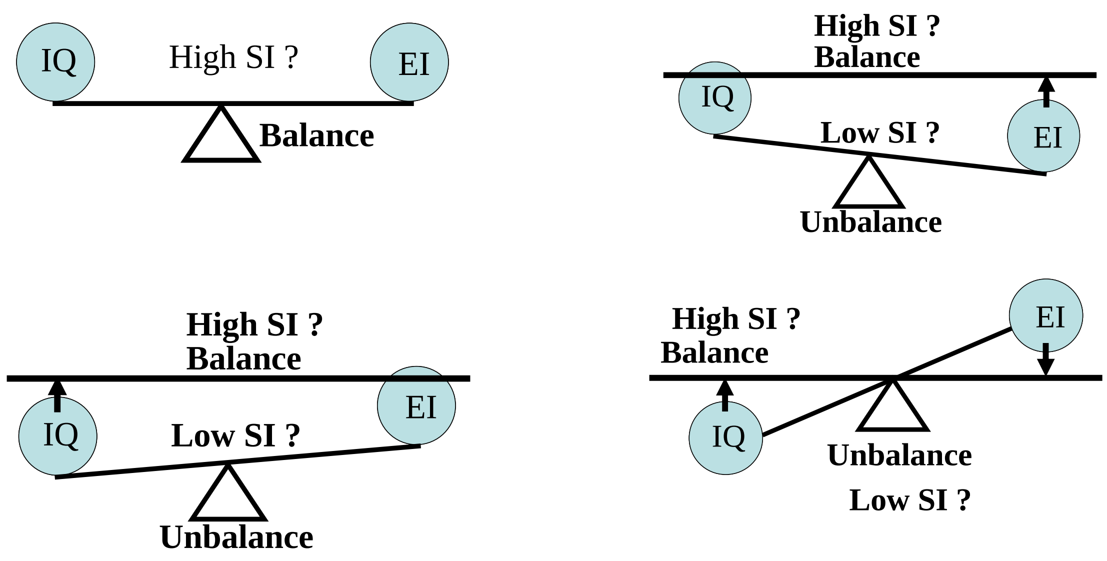

Figure 6. Balance between IQ and EI.

4.5 SI necessary for prevention of violation

As mentioned in 4.4, how to cope with risk and uncertain society must exist in the balance between EI and IQ (Figure 6).The following four examples are demonstrated to discuss how improper balance between IQ and EI leads to improper behavior.

(Case1)

Due to lack in knowledge of risk information (IQ aspect), we tend to sensitively react to risk information reported by mass media (for example, safety problem in nuclear power plant or Okinawa group suicide problem) (EQ aspect). We tend to be insensitive to knowledge of risk information. We tend to be sensitive to risk information. This corresponds to an unbalanced situation between IQ and EQ. It is possible that such an attitude leads to improper behavior. In such a case, we should not sensitively react to risk information before confirming its properness and reliability. Using IQ, we should first evaluate the risk information objectively and scientifically.

(Case2)

When a scandal or an accident occurs in an organization, the organizational top management tends to behave as follows. They leave the collection of information (IQ aspects) concerning the present state such as the distortion in organization to others, and are very insensitive to such an activity. However, they quickly tend to behave to hide the scandal or the accident and muzzle organizational members, and are very sensitive to such an activity (EQ aspect). We tend to be insensitive to the collection of knowledge of scandal or accident occurring within an organization. Simultaneously, we tend to be sensitive to hiding information related to a scandal or an accident and muzzling organizational members. This corresponds to an unbalanced situation between IQ and EQ. SI of such an organization does not seem to function. We should be insensitive to such an activity as hiding information on a scandal or an accident.

(Case3)

There exist some subordinates who sensitively react to being scolded by the boss and feel depressed easily (EQ aspect). Such persons don't tend to pay attention to important information such as collection of customer information (IQ aspect). In other words, they are apt to be very insensitive to such information. Such an attitude would never lead to proper behavior. In such a situation, they should be sensitive to the collection of important information. Although they tend to sensitively react to being scolded by the boss, they should be insensitive to such a circumstance, and obediently accept what the boss advised them.

(Case4)

In 2005, the Japanese House of Representative dissolved based not on the non-confidence of cabinet but on the rejection of bill on privatization of national post office. This was the first time in the history of Japanese constitutional government. Citizens were very insensitive to the knowledge that the dissolution should be carried out in order to be evaluated by citizens whether the cabinet in general is reliable or not. Once the dissolution based on a single bill is carried out, the House of Representative must be dissolved every time the discussion on a very important bill is in balanced situations (IQ aspects). Contrary to this, citizens were very sensitive to the meaningless catchphrase by a popular prime minister which was agitated by mass media (EQ aspect). Citizens were very insensitive to the true importance of knowledge or information such as significance concerning dissolution of House of Representative

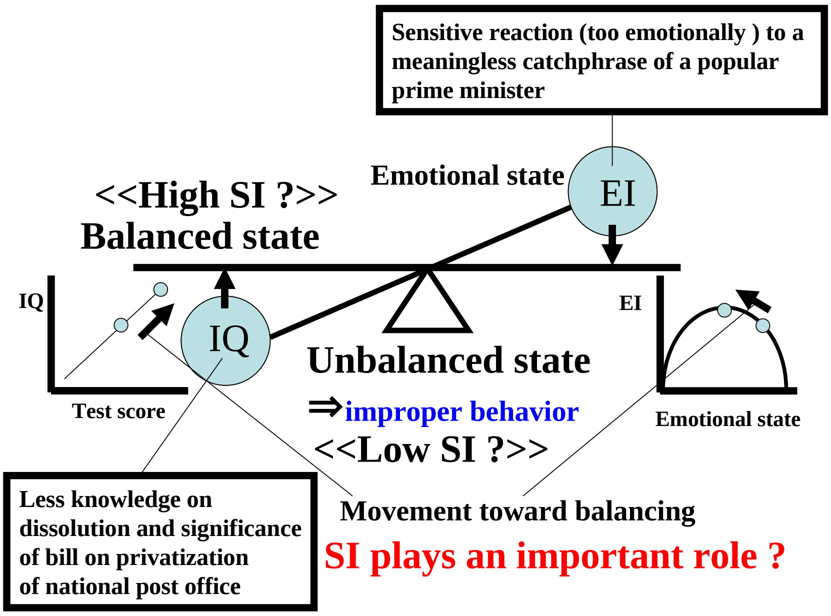

Figure 7. Explanation of unbalance between IQ and EI in Case4 of Section 4.5.

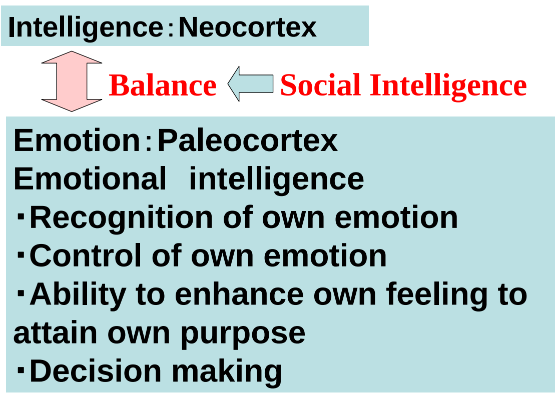

Figure 8. Function of social intelligence to balance between IQ and EQ.

and criticality of privatization of national post office (At present, citizens must have noticed that pension problem, medical service for super-older adults, and specific road fund are more important than privatization of national office). SI of citizens does not seem to work smoothly and properly. In such a case, we should be more sensitive to the knowledge or information above mentioned. Although we tended to be sensitive to one word catchphrase of a prime minister, we should be insensitive to such a catchphrase, and evaluate the nature of it carefully. The unbalanced state in this case is summarized in Figure 7.

Eventually, high (proper) balancing impresses people and society. In art, the balance between technique (aspect of IQ) and artist's emotional intelligence might give rise to works that impress many people. In sports, the balance between technique (aspect of IQ) and emotional intelligence of teams or players can create teams or players that impress many people. Players or teams without emotional intelligence cause social problems or scandals such as evading taxes or receiving bribe.

Cognition of risk based on emotional and sensational information by mass media will be discussed. Is EI less important than IQ? EI is based mainly on peripheral rout processing. IQ is based mainly on central rout processing, and is related to motivation and ability. Information on error, accident, and risk is asymmetric. An example of this is lemon market (used car market). Reliability between sender and receiver of information is important. Social intelligence (SI) must work to balance between IQ and EI. These concepts are summarized in Figure 8.

Not only IQ but also EI must be endowed with. Does social intelligence(SI) make this possible？To realize this and prevention violation and groupthink, social dilemma mentioned below must be solved and effective measure to exceed critical mass must be proposed.

4.6 From closed (relief) society to global (reliability) society

In closed society, we can easily get relief. Relief corresponds to Japanese word "Wa" (obedience) in a narrow sense. It is possible that such society easily falls into groupthink, and a disastrous accident or scandal might consequently occur. These days, our society is changing from closed to global society. Totalism (Globalism) requires us to change our mentality from relief to reliability. Such a situation gives rise to social dilemma [20]-[23]. Social dilemma means that we don't tend to select cooperative behavior in spite of understanding that cooperative behavior is helpful and necessary. For each individual, taking non-cooperative behavior

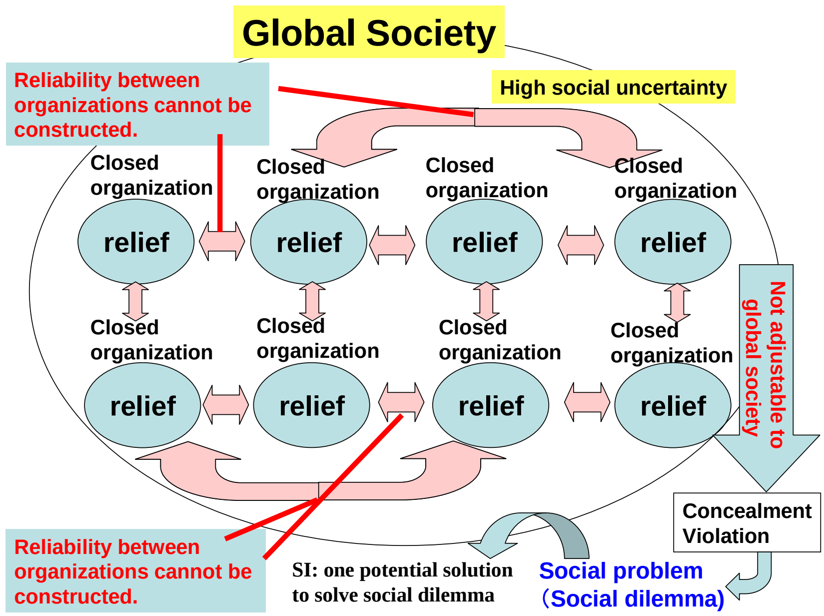

Figure 9. From relief (closed) to reliability (global) society.

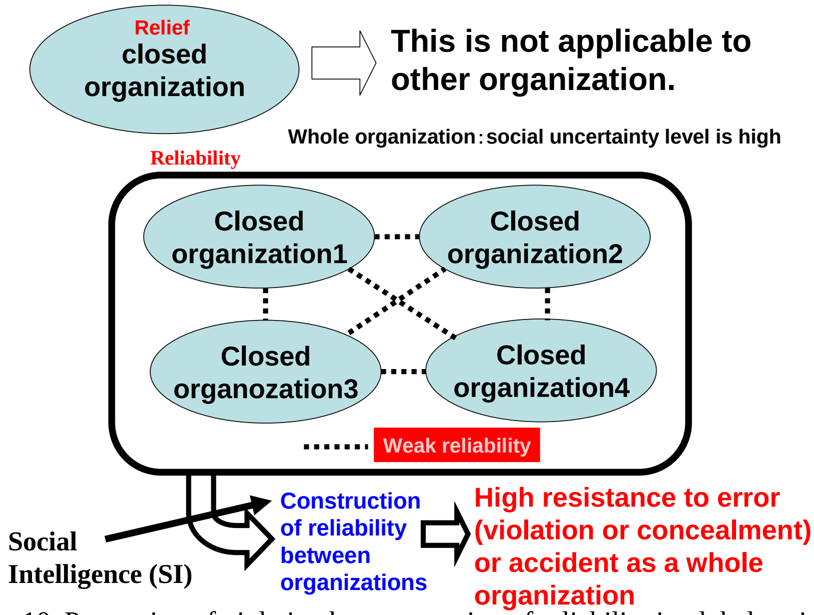

Figure 10. Prevention of violation by construction of reliability in global society.

induces more desirable results than cooperating. However, if all members in society or organization take non-cooperative behavior, undesirable results arise. We should not yield to social dilemma, but construct environment where every member can cooperate. If we can't cope with global society, we cannot help suffering from scandals or concealments. This is what is called chain of unreliability. Insufficient social intelligence is one cause of violation. Ability to grasp personality, human relation, and reliability, or to balance between IQ and EI can avoid violation-based accidents or scandals. This ability must be closely related to social intelligence (SI). The concepts are summarized in Figure 9 and Figure 10.

Why do we stick to one behavior, even if we know that such a behavior is not recommended? This leads to violations or concealments. It is important to clarify this mechanism and propose a system that can effectively avoid social dilemma. The models that might be promising to solve such violations or social dilemma [20]-[23] include the following.

(a)Modeling of social dilemma by theory of game [20]-[23]

(b)Modeling of social dilemma by hyperbolic curve of discount [24]

(c)Model of social dilemma by assuming limited reasonability of human [14]-[15]

(d)Modeling of social dilemma by habit or instinct

4.7 Approach to violation prevention based on reliability and safety of organization

Balance between emotional intelligence (EI) and intelligence (IQ) is one of the useful measures for the prevention of organizational violation. To facilitate an approach for the prevention of violation based on reliability and safety of organization, the following might be promising and effective:

(1)Building of model on bias of social cognition

(2)Clarifying mechanism of groupthink or violation

It is possible that a bias of social cognition leads to formation of stereotype, and eventually to groupthink. Formation of reliability and commitment relationship is necessary to carry out the approaches (1) and (2) above. Good relationship with partner is more and more important under social environment with high uncertainty. Without this, the organization cannot be tolerable to unpredictable errors or accidents.

Social environment which is formed and maintained by acquiring some properties includes uncertainty, danger, and risk. Social intelligence (SI) which can adequately assess the reliability of others must be acquired in such environment. Organizational manager need to acquire such ability or social intelligence (SI). Organizations which have many managers like this must be robust to accidents, scandals, or errors.

5. Conclusions

How serious accidents or scandals occurred due to human errors (especially, violation) has been discussed and a proper addressing measure has been conceptualized in the framework of social intelligence and distortion of decision making. A secret to prevent violation might exist in the elucidation of how social intelligence balance between IQ and EI and give rise to reliability of an organization. The construction of social structure or system that enhances social intelligence (SI) as an organization would be helpful to prevent violation-based accidents or scandals.

Although it is believed that the traditional safety education can change attitudes or mind toward safety by means of education based on only IQ aspects, accidents or scandals frequently occur. These problems including social dilemma which lead to violation must be approached on the basis of the full understanding of social system and construction of reliable society by means of the enhancement of social intelligence (SI). We believe that social intelligence (SI) which enables us to adapt to reliability society is a secret to the reduction of violation that leads to disastrous managerial (organizational) accidents or scandals.

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