Two Different Mechanisms of Formation of Flashbulb Memories

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One hundred seventy-nine subjects took part in a test-retest study to investigate the formation of flashbulb memories (FMs) related to two notable events in 1995: the Nerve Gas Assassins' Attack and the Gubernatorial Election in the Tokyo Metropolitan District. A causal analysis using the structural Equations (EQS) technique showed that the formation of FMs related to the former was primarily associated with the level of IMPORTANCE AND ESTIMATION of the event, while that of FMs related to the latter was primarily associations with AFFECT. These results suggest that the mechanisms of FMs formation do not converge into one mechanism. The implication of these findings is that studies of the formation of FMs need to take account of the characteristics of the events triggering them.

KEYWORDS: FMs, mechanisms of FMs formation, EQS

1. Introduction

Studies of flashbulb memories (hereafter referred to as "FMs"; see below for discussion of definitions) have mainly focused on the memories of great shocking events that were public in the West. In historical retrospect, for example, in 1963 the assassination of President John F. Kennedy formed FMs in people both in America and Canada (Yarmey & Bull, 1978), and in 1968 that of Martin Luther King Jr. produced other FMs only for black people in America (Brown & Kulik, 1977). On February 2–3, 1990, the Emory Cognition Project Conference on FMs was held, and there the primary theme focused on the explosion of Space Shuttle Challenger in 1986 (Winograd & Neisser, 1992). A few events of similar import also occurred in Europe. In Sweden, Prime Minister Olof Palme was assassinated (Christianson, 1989); in Spain, General Bahamonde Franco died of advanced age (Brown & Kulik, 1977); and in Britain, there was the sudden resignation of former Prime Minister Margaret Thatcher in 1990 (Conway et al., 1994). All FMs discussed here had a common feature except for the sudden resignation of Margaret Thatcher. Namely, they related to events associated with unexpected deaths.

These events, on the other hand, might not apply in Japan, because many years have passed since the assassinations of VIPs never occurred, or a politician to be anticipated as a national-hero was rarely born (Takagi, 1990). However, two widely publicized shocking events with different features occurred consecutively in Japan in 1995: the Nerve Gas Assassins' Attack in the Tokyo Metropolitan subway on 20 March ("Assassins"); and the election of a famous TV personality as Governor of the Tokyo Metropolitan District On 9 April ("Governor"). In Assassins, an *indiscriminate* terrorist attack led to the deaths of eight passengers and injured approximately 3,800 in the underground railway system (Murakami, 1997). In Governor, almost everyone knew him, but very few expected him to be nominated. Both events were therefore highly surprising and consequential. These two events provided a unique opportunity to investigate FMs.

Before continuing, it is necessary to specify which definition of FMs is to be used here. There are two classical definitions of FMs. One is a strict definition (Brown & Kulik, 1977) and the other is a lenient one (Winograd & Killinger, 1983). After firstly stating these two definitions, we shall present our own definition.

FMs were defined by Brown and Kulik (1977) as memories of the circumstances on hearing about a highly surprising and consequential event. These memories are characterized as like a photograph, to show very little forgetting, and are produced by a special-purpose biological mechanism (Brewer, 1992). Because this strict definition requires perfect accuracy of FMs in canonical categories (for example, free description, activity, people, place and source), it is heavily loaded with the burden of proof (Schmit & Bohannon, 1988). Moreover, it is also open to the criticism that it naturally leads to the notorious copy theory (e.g., Brewer, 1992; Omori, 1996). Winograd and Killinger (1983) thought that FMs did not necessarily need the perfect accuracy of these canonical categories and, in contrast to the strict definition, proposed a more lenient one. They required to subjects to answer the circumstances question plus the recall of one or more canonical categories. Neisser and Harsh (1992) drastically changed the definition of FMs from one based on accuracy to one based on consistency of the canonical categories, because the use of memory accuracy is liable to reduce subjects' answers to correct-or-incorrect (i.e., all-or-none), whereas in fact many subjects' memories were partly right and partly wrong (Neisser & Harsh, 1992). If we adopted memory accuracy as the dependent variable in spite of the past always too vague to

assure the content of it (Sasaki, 1996), to study memory, especially on the everyday memory research, would end in a fiasco. Here, therefore, we adopt the Neisser and Harsh definition of more lenient criteria, and are able to include less surprising and consequential flashbulb events than those of unexpected deaths like the assassinations of international VIPs.

Only Conway et al. (1994) investigated the mechanism of FMs. According to their results, the sudden resignation of Margaret Thatcher caused FMs due to subjects' prior KNOWLEDGE AND INTEREST. These results were not sufficient to explain FMs formation in general however, because these memories might be highly dependent on the characteristics of triggering events. The present study could determine whether or not FMs related to sudden deaths have a different mechanism to those which are not. In order to confirm whether or not two different FMs have the same mechanism, we use the causal analysis of structural Equations (EQS) approach of Bentler (Bentler, 1995; Bentler & Wu, 1995).

2. Method

Flashbulb memory questionnaire

The Flashbulb memory questionnaire (FMQ) was modeled on the questionnaire designed by Conway et al. (1994), but slightly modified. One of the differences was that Conway et al. gathered information on political opinion, whereas we did not because we were not interested in political opinion.

The front cover of the FMQ contained an introduction that informed subjects that the study focused on memories of public events and, in particular, on memories of their own personal circumstances when they first heard the news of each major public event. The assassination of American President John F. Kennedy was illustrated, and it was explained to subjects that many people in America over the age of 40 years could recall who they were with, what they were doing, and where they were when they first heard the news of the assassination.

The FMQ had three sections. Part 1 of the FMQ required a description of each event, Part 2 assessed specific aspects of each event, including original affect and subsequent rehearsal, and the purpose of Part 3 was to gather information on importance of each event. Our composition of the FMQ is shown in the Appendix. The last parenthesis of each question in the Appendix contains an abbreviation of the measured variables illustrated in Figures 4 and 5.

Subjects

Two hundred and eighty-three subjects participated in the test, and 231 in the retest both as a group. All were students attending Tohoku Fukushi University, Sendai, Japan. As 179 subjects were common to both groups, the available data were taken from those 179 subjects. Their mean age was 20.3 yr.

Procedure

We used a large-scale test-retest study of FMs. All subjects were provided with a copy of the FMQ, then they were prompted to complete it and did not consult with others about the contents or their answers during the test. Subjects were told on the following pages the two major public events that had recently occurred in Japan, and it was explained that their task was to try to recall their personal circumstances when they first heard the news. Subjects then answered all three sections of the FMQ, taking 40 to 50 minutes to complete it.

Firstly, subjects were asked to answer "yes" or "no" to the question "Do you recall the circumstances in which you first heard of the Nerve Gas Assassins Attack in the Tokyo Metropolitan subway?", and that "a famous TV personality was elected Governor of Tokyo Metropolitan District?" Subjects who answered "yes" then went on to complete all parts of the FMQ, and those who answered "no" skipped the memory description of Part 1, answered any questions they could in Part 2 (guessing was permitted if necessary), and answered all questions in Part 3.

For the memory description in Part 1, subjects were instructed to write a short description of each event— about a paragraph in length. Following this, there was some space for them to list any other memories recalled when they first heard the news of the events. Subjects were not given any direction about the type of memories that might come to mind, and were simply asked to write a short description of the content of any memories that spontaneously occurred to them.

At retest they were not reminded that they had completed the same questionnaire approximately six months ago, and they participated in the FMQ again. The test was administered on 16 May, and the retest on 11 November. By coincidence, the autocrat of aum Supreme Truth cult, Chizuo Matsumoto, was arrested on the same day of the test.

3. Results

The results are divided into five sections in the following text. In the first section, we describe how we score

the consistency of FMs. In the second section, we confirm which canonical categories are associated with FMs. The proportion of subjects of each consistency score is reported next. The procedure in this section is strongly related to our operational definition of FMs. In the fourth section, before reporting the EQS procedure, we conduct factor analysis in order to explore some latent variables, and then report two causal models for the two major public events in the last section.

The two measured variables—other memories ("O-MEMS") and the date of the event ("F-HAP")—are scored as follows. The number of any other memories is the index O-MEMS. The index F-HAP concerns whether the date of the event is indicated correctly. A zero score denotes that the subject did not answer the date of the event at all, and a one indicates that they responded with the correct year only. A two indicates that they supplied the year and month of the event correctly, and on a three information was perfectly correct.

Scoring the consistency of FMs

In scoring consistency, we followed a procedure developed by Neisser and Harsch (1992). There were five canonical categories: memory description, people, place, ongoing activity and information source. In this procedure, each canonical category, such as "ongoing activity", was assigned a score of a zero, one or two. A zero score indicated that the subject either forgot the attribute (i.e., did not complete the question in the FMQ) or attributed it to a different explanation at retest (e.g., at test answered "intended to write a report on the lecture at university" and at retest answered "relaxed while watching TV"). A one denoted a basically, but not exactly, consistent response (in this case, the subject responded with "watching the sudden news" at test and with "watching TV with my family" at retest). A two indicated that the subject response was *exactly* consistent. In this case, he or she answered with identical information both at test and at retest, or he or she responded with new additional information at retest, besides *all* information already mentioned at test. Every subject was assigned a score of a zero, one or two for each canonical category, according to the correspondence between their test and retest responses. For every subject, scores were ascribed separately by two independent evaluators, and the lowest percentage of agreement between the two evaluators was 89.4%. The comparatively small discrepancies were resolved in discussion between the two evaluators.

The consistency score included all five canonical categories. This score was calculated not from accuracy, but from the consistency between the test and retest scores. This procedure freed the analysis from considerations of memory accuracy[1].

Association of canonical categories with FMs

The operational definition of FMs required canonical categories. A consistency score was compiled from the five canonical categories corresponding to those identified in the study of Conway et al. (1994) and in other studies. Nevertheless, not all the canonical categories already mentioned were exactly identical. For example, both Brown and Kulik (1977) and Pillmer (1984) considered the following canonical categories: place, ongoing activity, informant, one's own feeling, others' feelings and aftermath. On the other hand, McCloskey, Wible and Cohen (1988) used location, activity, source and reaction. Hence, we had to confirm which canonical category associated most strongly with the FMs.

In order to explore the consistency of canonical categories for the two FMs, we conducted MANOVA on the scores assigned to each category. In this analysis, we treated canonical categories as within-subject with five levels (description, people, place, activity, and source). Because we were only interested in which canonical category for each flashbulb event was the most highly consistent, we conducted a multiple comparison method.

In Figure 1, the consistency score for each of the five canonical categories is depicted for Assassins, and in Figure 2 for Governor. These Figures clearly demonstrate that the five canonical categories were not equally related to FMs [Assassins, $F(4,740) = 31.43, p < 0.01$; Governor, $F(4,728) = 88.19, p < 0.01$]. Subjects' memories of Assassins were significantly more consistent in the two categories of place and source than in any other categories [$p < 0.05$]. For Governor, memories were also significantly consistent in categories of place and source [$p < 0.05$]. Categories other than place and source were therefore omitted from further analysis in the present paper.

Operational definition of FMs

The consistency score fell within a scale of zero to four. Throughout the remainder of this paper, we classified only full scores for FMs as a precise mirror of our operational definition. Further analysis was restricted only to the subjects retaining FMs. As a consequence, the number of subjects was reduced from 179 to 140 (78.2%) for Assassins and to 122 (68.2%) for Governor. Figure 3 shows the proportion of subjects who retained FMs for the two different events.
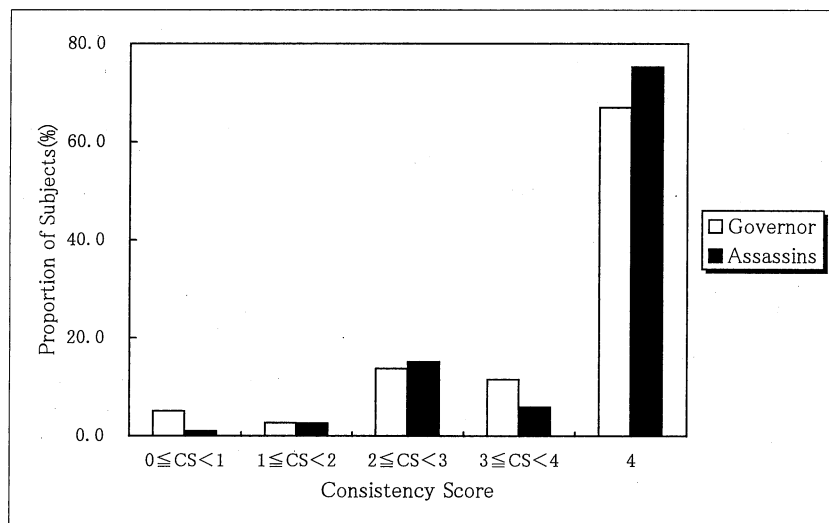
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[1]With protocol narratives, Mori (1996) also said that he did not focus on the accuracy of information reported by subjects.
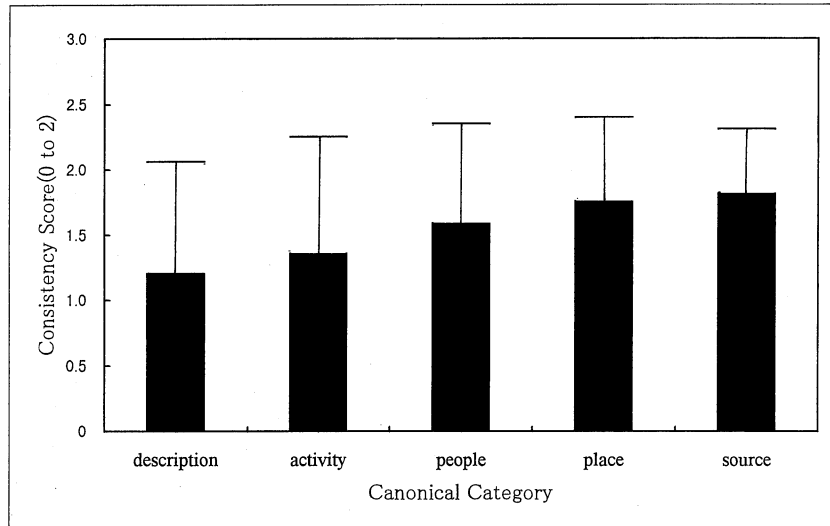
Fig. 1 Consistency score of five memory attributes for the Assassins data.
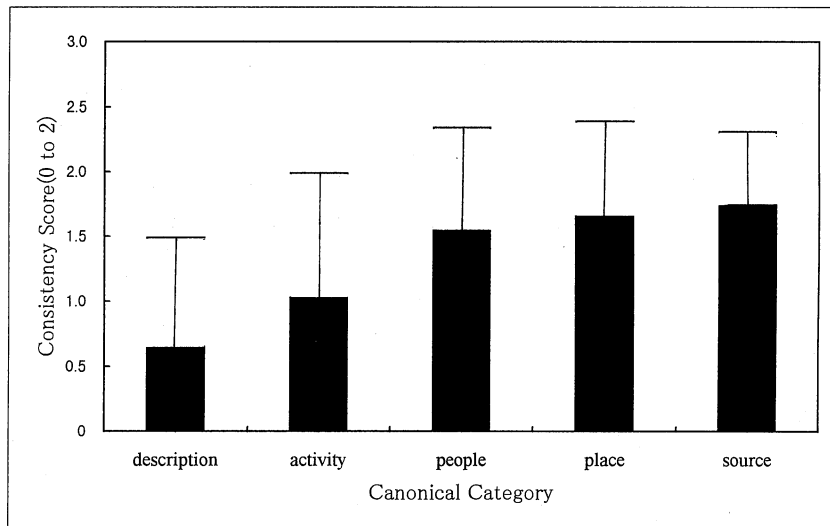
Fig. 2 Consistency score of five memory attributes for the Governor data.

Note   CS denotes Consistency Score

Fig. 3 Consistency score for the two different FMs.

Seeking latent variables

We examined which measured variables aggregated to form latent variables. In order to determine some identical latent variables, all data were summed up across the Assassins-Subjects-Group and the Governor-Subjects-Group. All intercorrelations between these variables were significant at the 1% level (mean = 0.451, S.D. = 0.151, max. = 0.737, min. = 0.168).

In order to specify the pattern of intercorrelations between these sets of variables in a more integrated and detailed manner, a causal modeling approach was adopted. For this analysis, the structural EQS approach was used. Before conducting EQS, latent variables were determined by using factor analysis. Firstly, data were confirmed as suitable for factor analysis (Determinant of Correlation Matrix = 0.031, Kaiser-Mayer-Olkin Measure of Sampling Adequacy = 0.929, Bartlett Test of Sphericity = 2376.55). The results of factor analysis are shown in Tables 1 and 2. After initial statistics were calculated by the method of PAF extraction, it was terminated when the initial cumulative factor contribution exceeded 75% of all the variances. With oblimin rotation, we interpreted the extracted factors from a matrix of factor loadings. The four extracted factors yielded the latent variables: IMPORTANCE AND ESTIMATION, REHEARSAL, AFFECT, and ASSOCIATED MEMORIES.

Mechanisms of the formation of FMs

Two models were generated, one for Assassins and the other for Governor, using the four latent variables. The causalities of these latent variables were examined for each FM using the EQS Program, and the two models were then compared in order to demonstrate whether or not the two sets of FMs had the same mechanism. The model of the Assassins FM will be presented first.

Data on Assassins

Figure 4 was a good statistical fit to the data [Goodness of Fit Index (GFI) = 0.891, R-Squared: $\eta_{rehearsal}$ = 0.730; η_{affect} = 0.328; $\eta_{associated\ memories}$ = 0.208, respectively]. From the GFI, the model in Figure 4 could explain the 89.1% variance of the sample-covariance matrix. Notwithstanding this score, the GFI does not include a measure of the stability of the adopted model (Toyoda, 1992). Consequently, the coefficient of R-Squared was calculated. Because residuals in Figure 4 did not highly determine the causality as could be understood from three coefficients of R-Squared, we adopted this model.

In considering the paths between IMPORTANCE AND ESTIMATION and the three other latent variables, it is clear from Figure 4 that the IMPORTANCE AND ESTIMATION variable is central to Assassins FMs in that this variable contributed significantly to all other latent variables. For instance, the IMPORTANCE AND ESTIMATION variable directly contributed to the variance of AFFECT: on this path, the standardized solution of IMPORTANCE AND ESTIMATION with AFFECT was 0.57. On the contrary, the three remaining latent variables other than IMPORTANCE AND ESTIMATION were unconnected: for example, REHEARSAL did not contribute to AFFECT.

Table 1   Oblimin-rotated pattern matrix for the FMQ.

Variable Items	Factors 1	2	3	4	h^2
EST	**-0.629**	0.134	0.067	0.096	0.708
NI	**-0.844**	-0.023	0.033	0.011	0.714
PI	**-0.277**	0.188	0.216	0.230	0.594
INTR	**-0.330**	0.274	0.183	0.121	0.626
SPO	-0.067	**0.852**	0.010	0.034	0.688
THO	-0.110	**0.863**	0.067	-0.053	0.795
WAT	-0.237	**0.551**	-0.050	0.067	0.561
SUR	0.067	0.018	**0.747**	-0.088	0.587
INTE	0.043	0.002	**0.748**	0.108	0.607
F-HAP	-0.045	-0.003	0.059	**0.548**	0.328
O-MEMS	0.029	0.002	0.019	**0.547**	0.286

Note: Factor loadings greater than | 0.25 | are shown in boldface.
h^2=variables communialities.

Table 2   Oblimin-rotated structure matrix for the FMQ.

Variable Items	Factors 1	2	3	4	h^2
EST	**-0.825**	**0.712**	**0.651**	**0.519**	0.708
NI	**-0.845**	**0.634**	**0.601**	0.415	0.714
PI	**-0.685**	**0.680**	**0.650**	**0.583**	0.594
INTR	**-0.727**	**0.723**	**0.671**	**0.532**	0.626
SPO	**-0.603**	**0.828**	**0.589**	0.482	0.688
THO	**-0.685**	**0.890**	**0.663**	0.468	0.795
WAT	**-0.652**	**0.732**	**0.542**	0.467	0.561
SUR	**-0.558**	**0.552**	**0.762**	0.334	0.587
INTE	**-0.535**	**0.563**	**0.774**	0.467	0.607
F-HAP	-0.319	0.340	0.312	**0.572**	0.328
O-MEMS	-0.246	0.287	0.260	**0.535**	0.286

Note: Factor loadings greater than | 0.50 | are shown in boldface.
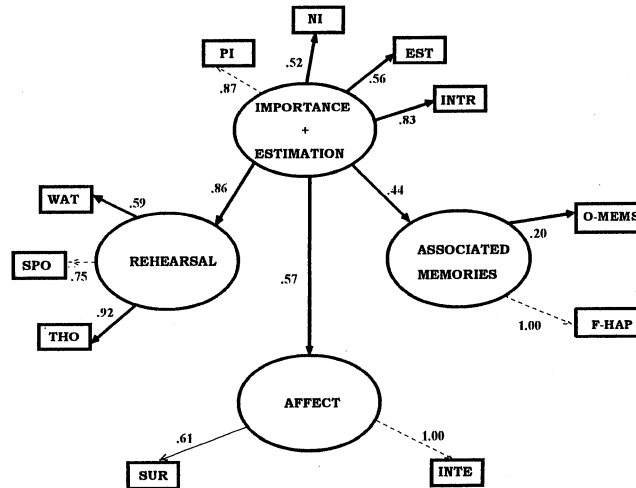
Fig. 4 Causal model of the relations among latent and measured variables for FM for the Assassins data. The four la-
tent variables are represented by circles, and the 11 measured variables as rectangles. All paths between the latent
variables were positive and significant. A dashed arrow from a circle to a rectangle signifies a fixed path. A bold solid
line from a latent variable to a measured variable denotes a significant path; a fine solid line represents no sig-
nificance. An arrow originating at one variable and terminating at another indicates that the former variable contrib-
utes to the determination of the variance of the latter.
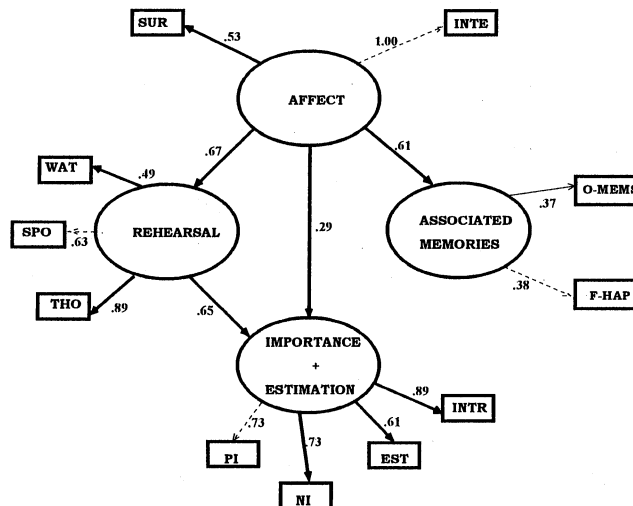

Fig. 5 Causal model of the relations among latent and measured variables for FM for the Governor data (conventions
as in Fig. 4).

Thus, according to the path diagram in Figure 4, IMPORTANCE AND ESTIMATION determined both AF-
FECT and REHEARSAL to a great extent and ASSOCIATED MEMORIES to a lesser extent. That is, the
greater the degree of IMPORTANCE AND ESTIMATION, the higher the levels of AFFECT, REHEARSAL
and ASSOCIATED MEMORIES.

Data on Governor

The same analysis was used as for the Assassins. Figure 5 also shows a good fit to the data [GFI = 0.892, R-
Squared: $\eta_{rehearsal}$ = 0.452; $\eta_{estimation+importance}$ = 0.760; $\eta_{associated\ memories}$ = 0.376, respectively]. From the GFI, the
model in Figure 5 could explain the 89.2% variance of the sample-covariance matrix. Because residuals in
Figure 5 did not highly determine the causality as could be also understood from three coefficients of R-
Squared, we adopted this model.

On considering the paths between AFFECT and the three other latent variables for the Governor data in
Figure 5, AFFECT significantly determined the three other latent variables, but the other latent variables were
not always directly interconnected. For example, AFFECT directly contributed to the variance of ASSOCIAT-
ED MEMORIES, REHEARSAL, and IMPORTANCE AND ESTIMATION, but note that, in Figure 5, from
ASSOCIATED MEMORIES to ESTIMATION or vice versa, there is no arrow. On the paths from both AF-

FECT to ASSOCIATED MEMORIES and to REHEARSAL, the values of the standardized solutions were 0.61 and 0.67, respectively. There were two pathways from AFFECT to IMPORTANCE AND ESTIMATION, that is a direct path and an indirect path. The indirect path via REHEARSAL had a stronger causality than the direct path.

4. Discussion

The major finding of the present study is that FMs are not always produced from a single mechanism, as demonstrated by the large difference in the causal mechanisms of the two events depicted in Figures 4 and 5. Prior to our study, the various kinds of FMs studied, such as those arising from the assassinations of VIPs and the sudden resignation of Margaret Thatcher, showed striking similarities which did not decay over a long period, and were therefore labeled identically as "FMs". However, it has not been proved that they were produced by an identical mechanism. In order to demonstrate different mechanisms in different "FMs", we administered causal analysis using EQS.

Two obviously different events were compared so as to ascertain whether or not different "FMs" have an identical mechanism. FMs related to Assassins relied mostly upon IMPORTANCE AND ESTIMATION of the triggering event, while those for Governor did mostly upon AFFECT. Cognitive psychologists studying FMs treated them as if they were formed by a single mechanism, but the present study strongly indicates that there are at least two different mechanisms in the formation of FMs.

Compared to the present results, Conway et al. (1994) discovered an entirely another mechanism in the formation of FMs. According to their results, the latent variable subjects' prior KNOWLEDGE AND INTEREST to former Prime Minister in Britain Margaret Thatcher caused the FMs. It is therefore concluded that FMs are not established by a single mechanism, but by mechanisms highly dependent on the characteristics of the triggering events, and therefore the studies of the formation of FMs need to consider the characteristics of them.

Acknowledgments

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Appendix[2]
Composition of the Flashbulb Memory Questionnaire
Part 1

(1)   Do you recall the circumstances in which you first heard of _____ ? (yes or no.)

(2)   Write a short description of the circumstances in which you first heard about _____ (free description.) (MEMORY DESCRIPTION)

(3)   When you first heard the news of _____ , how many other memories occurred to you? You may write as many other memories as you can remember. (free description.) (O-MEMS)

Part 2

(4)   Did you first hear this news from any other person? (yes or no.) (INFORMATION SOURCE)

(5)   Did you first hear this news from the media? (yes or no.) (INFORMATION SOURCE)

(5a)   If you first heard the news from the media, which one? (newspaper/radio/television/other.) (INFORMATION SOURCE)

(6)   Who were you with when you first heard the news? (List names: .) (PEOPLE)

(6a)   Were these: A] Friends B] Relations C] Colleagues D] Other?

(7)   Where were you when you first heard the news? (free description.) (PLACE)

(8)   What were you doing when you first heard the news? (free description.) (ACTIVITY)

(9)   How surprised were you when you first heard the news? (3 means extremely and 1 means not at all.) (SUR)

(10)   *What emotion (other than surprise) did you feel? (Write name of the emotion or feeling.)

(11)   How intense was your emotion or feeling? (3 means very intense and 1 means not intense.) (INTE)

(12)   How often have you thought about this event since it happened? (3 means very frequently, 2 means occasionally, and 1 means not at all.) (THO)

(13)   How often have you spoken about this event since it happened? (3 means very frequently, 2 means occasionally, and 1 means not at all.) (SPO)

(14)   How often have you read, listened to and/or watched anything about this event since it happened? (3 means very frequently, 2 means occasionally, and 1 means not at all.) (WAT)

(15)   When exactly did this event take place? (year, month, date, day, time to nearest minute-guess if you have to.) (F-HAP)

(16)   *When exactly did you first hear about this event? (year, month, date, day, time to nearest minute-guess if you have to.)

Part 3

(17)   How did you think importance of this event for you personally when you first heard the news? (3 means very important and 1 means not important.) (PI)

(18)   How did you think importance of this event for the country as a whole when you first heard the news? (3 means very important and 1 means not important.) (NI)

(19)   Do you think that this event was: A] One of the most biggest events B] One of an average events C] One of not big events. (EST)

(20)   How interested in are you in this event? (3 means very interested and 1 means not interested.) (INTR)

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[2]The two questions with an asterisk were omitted from the analysis, so they are not reported on further.