Exploring Effective Factors for the Generation of Innovative Ideas and Technologies in Functional Food R&D

Kosuke Kato[1], Shin Ito[1], Kazuhiko Itaya[1,2]
[1] Tokyo University of Agriculture and Technology, Tokyo, Japan
[2] Kagawa University, Takamatsu, Japan

***Abstract*—Functional foods are promising products with physiological effects that may provide health benefits. Innovative concepts and technologies that derive from individual creativity and serendipitous findings are indispensable in order to make good sales and achieve a share in the growing functional food market. However, there have been few reports discussing manufacturers in the food industry adapting any kind of a management system for promoting creativity and serendipity. In this paper, we demonstrate the analogy of the R&D processes between functional foods and drugs to point out the important role of serendipity in functional food R&D. To achieve our goal of constructing an effective management system for idea generation in the functional food sector, we conducted survey analysis of 114 R&D researchers and engineers at 74 companies in the sector using a questionnaire on idea generation. Through factorial analysis, we extracted the novel factors underlying idea generation in functional food R&D. We would like to show how these factors may promote creativity and serendipity.**

I. Introduction

The demand for a more convenient and less expensive means to reduce risk of disease and sustain health is increasing [4, 16, 24]. Compared to the use of drugs, functional foods precisely fit in the demand. Functional foods are products with physiological effects that may provide health benefits [24]. Compared to conventional foods, functional foods sell at higher prices and have larger profit margins [16], which makes the market attractive for food manufacturers. For these reasons, the continuing growth of the global functional food market is estimated to be around 10 percent per year [4, 16]. On the other hand, the development of these products is risky because of the specific requirements they must meet, incurring technological difficulties and high costs [24, 28, 29]. The challenges that a development group has to overcome is the specification of the functional ingredient as well as the evaluation of the physiological properties of the ingredient [16]. Additionally, the selection of an optimal food matrix and the development of an effective processing method is crucial in maximizing the bioavailability of the functional compound [4]. To make good sales and achieve a market share under these circumstances, companies need new management methods based on the development of core technologies [24], which differs greatly from the development strategies for conventional foods [18, 16].

Although food manufacturers struggle in the development of functional foods, pharmaceutical companies show interest in the sector because they have the advantage of experience in clinical trials, not to mention the low development cost and short development times of functional foods compared to those of pharmaceutical products [24]. Competition in the sector is increasing as pharmaceutical companies are now working together with food companies [4].

In the highly competitive functional food industry, innovative concepts and technologies that derive from individual creativity or unexpected findings are indispensable for a company to launch a successful product. However, there have been few reports discussing manufacturers in the food industry adapting any kind of management system to promote creativity and serendipity, even though the enhancement of idea generation may impact projects as a whole.

In this paper, we demonstrate the analogy of the R&D processes between functional foods and drugs to point out the important role of serendipity in functional food R&D. To achieve our goal of constructing an effective management system for idea generation in the functional food sector, we conducted a survey analysis of 114 R&D researchers and engineers at 74 companies in the sector using a questionnaire on creativity and serendipity. Through factorial analysis, we extracted the novel factors underlying idea generation in functional food R&D. We would like to show how these factors may promote creativity and serendipity.

II. Definitions

A. Creativity

The term ‘creativity,’ as used in this study, is a characteristic of a person’s output (work or performance) that others have found both original and in some way useful [2, 21, 23, 31], or “the production of novel and useful ideas by an individual or small group of individuals working together” [1].

Creativity is essential for organizations to promote innovation or to develop creative products [1, 12]. Therefore, it is ideal to enhance creativity within the R&D sites in order to effectively develop creative products. To consciously enhance creativity, we need to seek factors that can be modified artificially to some extent.

One of the first academic reports on creativity-affecting elements in an organizational research setting was done by Pelz and Andrews (1966). Researchers such as Amabile, Thagaard, and Dunbar further examined subjects to find some elements regarding the characteristics of individuals and work environments. Researches on applying these elements to

978-1-890843-36-6 ©2017 PICMET

Japanese R&D-sites were done by Niwa and colleagues [19, 20].

B. Serendipity

Serendipity has been defined in various ways, such as "the art of making an unsought finding" [27], "accidental discoveries" [17], "the ability to make a fortunate and unexpected finding by chance" [19], or "the accidental discovery of something that, post hoc, turns out to be valuable" [7].

In this study, though we acknowledge some overlapping regions between serendipity and creativity, we will tentatively refer to the findings which rely greatly on 'unexpectedness' as serendipity.

Serendipity has played an important role in the history of natural science and the development of technologies, and many epoch-making discoveries are said to be the results of serendipity. Just to name a few, Röntgen's discovery of X-rays, Fleming's discovery of penicillin, Hahn and Strassmann's discovery of nuclear fission, and the invention of Ringer's solution, 3M post-it notes, and Canon's inkjet printer [27, 30].

III. Creativity and Serendipity in Functional Food R&D

As we mentioned above, innovative concepts and technologies that derive from individual creativity or serendipity are indispensable for a company to launch a successful product. However, since the history of functional food is relatively short, there are few academic reports indicating the involvement of creativity and especially serendipity in the development of functional foods. On the other hand, there are a large number of drugs that are known to be results of serendipity. Kubinyi (1999) lists 53 compounds, including LSD and acetylsalicylic acid, as some of the drugs that were discovered due to serendipity. Ban (2006) also reports that serendipity played a role in the discovery of most prototype psychotropic drugs.

As we compare the development of functional foods with that of drugs, though there are differences concerning regulations and usage (for cure or for prevention), both are intended for healthcare and share a similar development process (Fig. 1). Additionally, the probability of a drug's entering the market is 1 compound out of 5,000 to 10,000 [22], and the probability of a launched food product's becoming a major hit is 0.3 to 1.0 percent, suggesting that both sectors should consciously aim for big hits by promoting creativity and serendipity.

Although there are few reports on serendipity, Ishii (2005) reports a serendipitous finding in the development of a FOSHU (FOod for Specified Health Uses) product of Kao Corporation (Japan), "Kenko ECONA," which contains diacylglycerol as a functional ingredient. In an interview with a Kao researcher, he comments, "At the time, we had been studying only the physicochemical aspects of diacylglycerol, but from my experience in nutritional chemistry, I wondered what would happen if we were to ingest it. The thought led to an experiment that showed that rats that were fed diacylglycerol decreased in serum triacylglycerol levels… The results gave me an idea… I started to think that oil with a less fattening function of diacylglycerol could become a blockbuster by changing the mindset of consumers." The researcher mentions 'gaining an insight' on 'something valuable' from 'an unexpected result,' which suggests that serendipity was involved in the discovery.

Assuming from the process of the discoveries mentioned above, the role of serendipity in functional food development may be as important as its role in the drug development of the last century. Therefore, promoting serendipity is expected to have a great benefit in the development of functional foods.

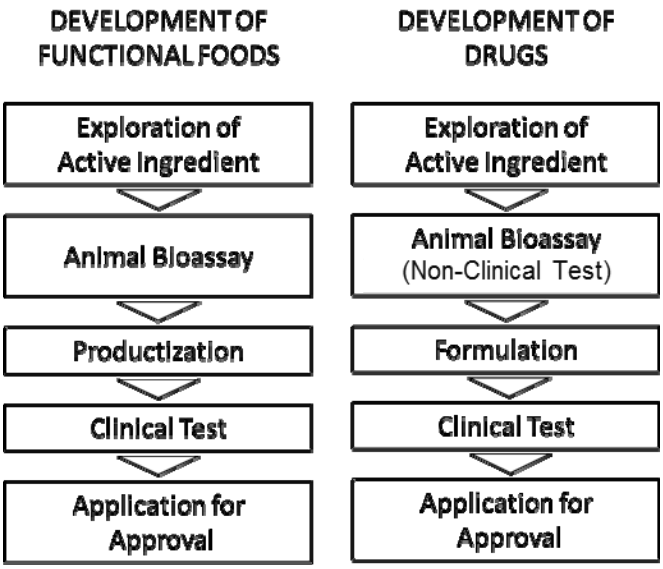

Fig. 1. Development Processes of Functional Foods and Drugs

IV. Theoretical Model

Based on the theory that elements in individuals and environments affect creativity [1], we have constructed a model in which factors in individuals and environments affect creativity and serendipity (Fig. 2). In the model, common factors in individuals or in environments affect the individuals and the environments in functional food R&D worksites, as well as the common factors in creativity or serendipity, which leads to the exertion of creativity and serendipity. The factors in individuals and environments are assumed to affect one another, though it is unclear what kind of factor is underlying or how they affect one another.

In this paper, we conducted a survey analysis of 114 R&D researchers and engineers at 74 companies in the sector using a questionnaire on creativity and serendipity. Through factorial analysis, we extracted the novel factors underlying idea generation in functional food R&D. We would like to show how these factors may promote creativity and serendipity.

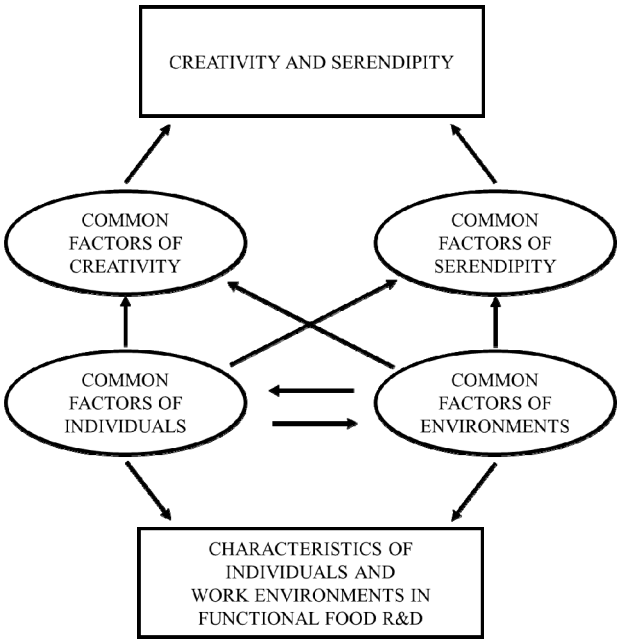

Fig. 2. Theoretical Model of Creativity and Serendipity in Functional Food Development

Arrows indicate the direction of influence.

V. METHODS

A survey was conducted from March through June 2016, and 76 Japanese companies holding three or more items approved by the Japanese Consumer Affairs Agency for FOSHU were studied. Data were collected from a total of 114 workers engaged in or with experience in the R&D of functional foods or health foods [13].

Data were collected by e-mailing participants the address of an online questionnaire website. Participants who visited the website were asked to answer 42 questions on idea generation with a 5-point Likert scale (wherein higher scores represent more acceptance) (Table 1) as well as 6 multiple-choice questions on the properties of the subject.

Statistical analyses and exploratory factorial analysis were conducted using SPSS Statistics version 23.0 (IBM). To assure the normality of the answers, each item was tested by Kolmogorov-Smirnov test prior to the rest of the analyses.

Structural equation modeling with the maximum likelihood method was conducted using SPSS Amos version 22.0 (IBM).

TABLE I. QUESTIONS ON IDEA GENERATION

Category	No.	Question[a]: Please indicate the extent to which you agree or disagree with each statement below.	References
Exertion of Creativity	cr1	I served as a good role model for creativity.	[26]
	cr2	I took risks in terms of producing new ideas in doing my job.	
	cr3	I generated novel but operable work-related ideas.	
	cr4	I found new uses for existing methods or equipment.	
	cr5	I demonstrated originality in my work.	
	cr6	I solved problems that had caused other difficulties.	
	cr7	I tried out new ideas and approaches to problems.	
Exertion of Serendipity	se8	I made mistakes which resulted in the ideas to reach my goals.	According to the definition [of serendipity, five sources of occurrence (mistakes, unrelated things, unexpected results, coincidental encounters, and external information) and two types of outcome (solutions for problems, and findings leading to different goals) were combined.
	se9	I made mistakes that led to completely new findings that I had never thought of.	
	se10	In order to reach my goals, I made use of information that at first appeared to be unrelated to my work	
	se11	I came up with completely new ideas from things that at first appeared to be unrelated.	
	se12	I came up with ideas useful for my work from unexpected results.	
	se13	I came up with ideas from unexpected results, which changed the goals of my work.	
	se14	I made use of information that I had coincidentally found for my work.	
	se15	I came up with ideas from people or information that I happened to encounter.	
	se16	I came up with solutions for problems in my work from conversations with others.	
	se17	I came up with completely new ideas from conversations with others.	
Character-istics of Individuals Concerning Creativity	ch18	I often take others' advice on my work.	[21]
	ch19	I have an interest in both pure science and application research.	
	ch20	I take different approaches from my colleagues.	
	ch21	I aggressively undertake difficult tasks.	[8]

TABLE I. QUESTIONS ON IDEA GENERATION (CONTINUED)

Category	No.	Question[a]: Please indicate the extent to which you agree or disagree with each statement below.	References
Characteristics of Individuals Concerning Serendipity	ch22	I get curious about the reason why I failed my challenge or experiment.	[27]
	ch23	I do my work and research myself.	[30]
	ch24	I am always concious of the goals and purposes of my work.	
	ch25	I have confidence in my knowledge on my field of work.	
	ch26	I often think about my work even when I am not at work.	[7]
	ch27	I take on challenges without fear of failure.	[14]
Characteristics of Organizational Structure Concerning Creativity	ch28	I usually work on tasks with adequate time schedules.	[3]
	ch29	I confer with my supervisor about setting my goals.	[11]
	ch30	Top managers in my company aggressively participate in research projects.	[11, 12]
Characteristics of Organizational Structure Concerning Serendipity	ch31	I often engage in work with deadlines.	[7]
	ch32	I cooperate with colleagues and collaborators.	
	ch33	There are experts in my company that I can consult.	[14]
	ch34	I can pursue the true value of my research without any concern for regular evaluations.	[20]
Characteristics of Organization Climate Concerning Creativity	35	I can reflect my opinions in my work.	[21, 25]
	36	I often exchange opinions with my colleagues.	
	37	I give priority to carrying out my company's policy.	[21]
	38	My workplace places great value on the workers' motivation.	[1]
Characteristics of Organization Climate Concerning Serendipity	39	My boss and colleagues often show positive reactions toward unexpected results and findings.	[7, 30]
	40	I have opportunities to talk with my colleagues and collaborators about things other than the present task or research.	[14]
	41	I have various opportunities to share information with other workers.	
	42	I can work freely to some extent without any concern for formal management.	[20]

[a] All the questions were asked in Japanese.

VI. RESULTS

A. Reliability of the data

Out of 114 observations, no incomplete forms were turned in. The Cronbach alphas of the two parts of the idea generation questionnaire ('exertion of creativity or serendipity' and 'characteristics of the individual or the working environment') were 0.86 and 0.78, respectively. All of the 42 items on idea generation qualified for normality, which suggests that they can be analyzed with parametric statistical methods.

B. Exploratory factorial analysis

We extracted the common factors underlying the items by exploratory factorial analysis (EFA) using the maximum likelihood method with Promax rotation.

By determining the transition point of the eigenvalues of the 17 items on 'exertion of creativity or serendipity' (scree test), a three-factor structure was assumed. Likewise, a three-factor structure was also assumed from the eigenvalues of the 25 items on 'characteristics of the individual or the environment.' An EFA was performed on the data based on the assumed structure. Items with loadings smaller than 0.4 were eliminated and the analysis was repeated on the remaining items until all items had a loading of 0.4 or larger.

The factors extracted from the items on 'exertion of creativity or serendipity' and 'characteristics of the individual or the working environment' were numbered Factors 1-3 and Factors 4-6, respectively. Each factor was given a new name based on the context of the items with high loadings in the subscale (Tables 2 and 3).

Factors 1 and 3 had strong correlations with Factors 5 and 6, while Factor 2 strongly correlated with Factors 4-6. This suggests that the common factors in idea generation are associated with multiple factors in individuals or the working environment.

C. Structural equation modeling

1) AnalysisModel

We constructed an analysis model according to the theoretical model (Fig. 3). Although there were some insignificant standard path coefficients, the expected values based on the theory and the actual data matched fairly well (Table 4). However, it was suggested that Factors 4 and 5 do not explain Factor 1, and Factors 5 and 6 do not explain Factor 2. Also, it was suggested that Factors 4 and 6 do not hold a covariance relationship, which corresponded with the low correlation observed in the EFA.

The major finding from the model was that the two factors with apparently contradictory meanings, Factor 4 *cooperative climate* and Factor 6 *non-conformity orientation* share the same function to promote Factor 3 *creativity*. Additionally, it is quite interesting that both factors enhance serendipity, but in a different way: Factor 4 promotes Factor 2 *serendipity from external information*, while Factor 6 promotes Factor 1 *serendipity from failures/unrelated information*.

The theoretical model assumed a covariance relationship between Factors 4 and 5, but there was a possibility that one factor might have a one-way impact on another. The theoretical model also does not consider direct influences between factors in creativity and serendipity, which we cannot completely deny.

TABLE II. RESULTS FOR EXPLORATORY FACTORIAL ANALYSIS ON EXERTION OF CREATIVITY AND SERENDIPITY SCALE (N=114)

Question Item	Factor Loadings[b]		
	I	*II*	*III*
Factor 1. Serendipity from failures/unrelated information			
se9	**.719**	-.064	.017
se8	**.715**	.024	-.050
se10	**.615**	.252	-.143
se13	**.539**	-.038	.250
se11	**.473**	-.022	.170
Factor 2. Serendipity from external information			
se15	-.076	**.841**	.075
se14	.172	**.553**	-.053
se17	.013	**.447**	-.028
Factor 3. Creativity			
cr3	.037	-.121	**.745**
cr7	-.125	.269	**.604**
cr1	.141	-.021	**.563**
Inter-factor correlations[c]			
	I	*II*	*III*
I	-	.587***	.613***
II		-	.536***
III			-

[b.] Loading factors >0.4 are in boldface.
[c.] ***p<0.01

TABLE III. RESULTS FOR EXPLORATORY FACTORIAL ANALYSIS ON CHARACTERISTICS OF INDIVIDUALS AND ENVIRONMENTS SCALE (N=114)

Question Item	Factor Loadings[d]		
	I	*II*	*III*
Factor 4. Cooporative Climate			
ch35	**.740**	.079	-.049
ch39	**.676**	-.253	.222
ch41	**.522**	.087	.038
ch40	**.478**	-.117	-.040
ch32	**.417**	.219	-.109
Factor 5. Challenge-minded			
ch27	-.045	**.698**	.090
ch21	-.105	**.691**	-.012
ch26	-.024	**.485**	.022
ch25	.301	**.433**	-.056
Factor 3. Non-conformity orientation			
ch24	.165	.133	**-.587**
ch42	.162	.078	**.571**
ch20	-.076	.027	**.541**
ch34	-.059	.320	**.524**
ch28	.162	-.053	**.501**
Inter-factor correlations[e]			
	I	*II*	*III*
I	-	.480***	-.167
II		-	.235*
III			-

[d.] Loading factors >0.4 are in boldface
[e.] *p<0.05***p<0.01

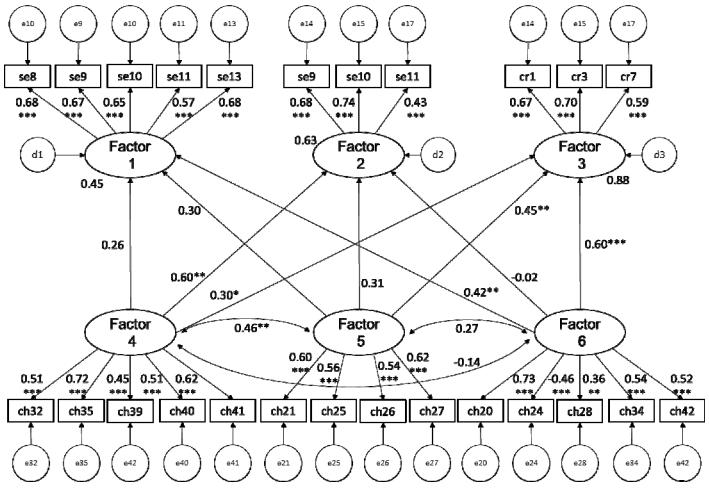

Fig. 3. Primary Creativity and Serendipity Model with Standardized Estimates

n=114. Path coefficients:*p<0.05, **p<0.01, ***p<0.001

TABLE IV. FIT INDICES FOR THE PRIMARY MODEL

Index	Value	Threshold value	Evaluation
CMIN/DF[f]	1.666	≤2	Good
CFI[g]	0.773	≥0.9	Fair
RMSEA[h]	0.077	≤0.1	Good

[f.] CMIN/DF: Chi-square divided by its degree of freedom
[g.] CFI: Comparative Fit Index
[h.] RMSEA: Root Mean Square Error of Approximation

VII. DISCUSSION

This paper focuses on evaluating the effects of individuals and environments on serendipity and creativity, which are sources of idea generation, to construct an effective management system in the functional food sector. A structured equation modeling was conducted regarding the results of the EFA, and it was suggested that characteristics of individuals and environments affect creativity and serendipity.

According to the result, one of the two factors in serendipity, Factor 1 *serendipity from failures/unrelated information* was positively impacted by Factor 6 *non-conformity orientation.* Non-conformity orientation is a style of behavior with focuses or logic different from general ones. Therefore, non-conformity-oriented researchers and engineers are capable of linking goals in work or completely new goals from things that may appear to be unrelated. Van Andel (1994) states, "Most serendipitists are open-minded, perceptive, curious, intuitive, smart, flexible, artistic, humorous, and diligent… As soon as he observes a surprising fact he interrupts and sometimes even stops his 'normal' work or program for a certain period," in which a great similarity with non-conformity orientation can be observed.

The other factor in serendipity, Factor 2 *serendipity from external information*, was positively impacted by Factor 4 *cooperative climate*. Cooperative climates can promote worker cooperation, thus increasing the input of external information, therefore linking to more serendipity. Cunha (2010) proposes that the occurrence of serendipity greatly involves bisociation (the mixture of cues from two contexts or categories of objects

that are normally considered separate). It was assumed that cooperative climates increase the amount of informational input, which may promote bisociation, leading to the exertion of serendipity. A number of empirical studies also report the correlation between worker cooperation and innovation, which supports our result [9, 10, 15].

Factor 3 *creativity* was impacted positively by Factor 4 *cooperative climate*, Factor 5 *challenge-minded*, and Factor 6 *non-conformity orientation*. Amabile (1988) describes a number of elements concerning cooperative environments that are conducive to individual creativity. She also specifies 'motivation to innovate' as the most important element in organizational innovation (the organizational analogue of individual creativity). She describes the term as "the forward-looking, risk-oriented vision," which can be referred to as challenge-minded. Additionally, Amabile (1988) names "an absence of conformity in thinking or dependence on social approval" as one of the characteristics of individuals affecting creativity-relevant skills, which is highly similar to non-conformity orientation. Overall, our results were consistent with Amabile's theory. Auernhammer and Hall (2014) also identified "willingness to innovate: individual's propensity to experiment with ideas even at risk of failure" and to "be open to change; encourage and value free communication and new and/or unusual ideas; tolerate mistakes" to be the determinants for creativity and innovation, which supports our result and discussion in whole.

All of the three factors in the characteristics of individuals and environments were closely associated with creativity and serendipity, and these findings were overall consistent with the preceding studies. We discovered critical factors impacting serendipity and elucidated pathways toward idea generation with an empirical approach, which provides a theoretical contribution to the study of idea generation in organizations. Finally, as a practical contribution of this study, the key factors that we demonstrated can be applied to R&D management, especially in the functional food industry, to develop an effective management method for idea generation. As a future challenge for R&D management, we suggest that in terms of promoting idea generation, organizational climate and technical leadership should be focused on not only creativity but also serendipity.

VIII. Conclusion

We conducted a survey analysis of 114 R&D researchers and engineers at 74 companies in the functional food sector using a questionnaire on idea generation and the working environment.

Our factorial analysis results pointed out six novel common factors underlying the idea-generation activities in the sector. The three common factors in the exertion of creativity or serendipity were *serendipity from failures/unrelated information*, *serendipity from external information*, and *creativity*. The three common factors in the characteristics of the individual or the working environment were *cooperative climate*, *challenge-minded*, and *non-conformity orientation*.

Structural equation modeling suggested that *serendipity from failures/unrelated information* and *serendipity from external information* were positively impacted by mainly *non-conformity orientation* and *cooperative climate*, respectively. Also, it was suggested that creativity was impacted by both *non-conformity orientation* and *challenge-minded*.

The findings in this paper may play an important role in developing an effective management method for idea generation in the functional food industry.

References

[1] Amabile, T. M.; A model of creativity and innovation in organizations. *Research in organizational behavior*, vol. 10, no. 1, pp. 123-167, 1988.

[2] Anderson, N., Potočnik, K., and Zhou, J.; Innovation and creativity in organizations: A state-of-the-science review, prospective commentary, and guiding framework. *Journal of Management*, vol. 40, no.5, pp. 1297-1333, 2014.

[3] Andrews, F. M., and Farris, G. F.; Time pressure and performance of scientists and engineers: A five-year panel study. *Organizational Behavior and Human Performance*, vol. 8, no. 2, pp. 185-200, 1972.

[4] Aryee, A. N., and Boye, J. I.; "Role and importance of health claims in the nutraceutical and functional food markets," in *Nutraceutical and Functional Food Processing Technology*, J. I. Boye, Ed. Chichester, UK: John Wiley & Sons, Ltd., pp. 347-374, 2014.

[5] Auernhammer, J. and Hazel H.; Organizational culture in knowledge creation, creativity and innovation: Towards the Freiraum model." *Journal of Information Science*, vol. 40, no. 2, pp. 154-166, 2014.

[6] Ban, T. A.; The role of serendipity in drug discovery. *Dialogues in clinical neuroscience*, vol. 8, no. 3, pp. 335-344, 2006.

[7] Cunha, M. P. E., Clegg, S. R., and Mendonça, S.; On serendipity and organizing. *European Management Journal*, vol. 28, no. 5, pp. 319-330, 2010.

[8] Dunbar, K.; "How scientists think: On-line creativity and conceptual change in science." in *Conceptual structures and processes: Emergence, discovery and change*, Ward, T.B. Smith, S.M. & Vaid, J., Eds. Washington D.C: American Psychological Association Press, pp. 461-492, 1997.

[9] Fuzi, Anita, Nick Clifton, and Gareth Loudon.; New in-house organizational spaces that support creativity and innovation: the co-working space. *R & D Management Conference*, Stuttgard, 3rd-6th June, 2014.

[10] Hülsheger, U. R., Anderson, N., and Salgado, J. F.; Team-level predictors of innovation at work: A comprehensive meta-analysis spanning three decades of research. *Journal of Applied Psychology*, vol. 94, pp. 1128-1145, 2009.

[11] Ikejima, M.; "R&D management in Japanese companies," in *International research management: Studies in interdisciplinary methods from business, government, and academia*, Birnbaum, P. H., Rossini, F. A., & Baldwin, D. R., Eds. New York: Oxford University Press, pp. 157-172, 1990.

[12] Ishii, M.; Research on scientists and engineers accomplishing innovative product development for national creativity. Second Theory-Oriented Research Group, National Institute of Science and Technology Policy (NISTEP), Ministry of Education, Culture, Sports, Science and Technology, Discussion Paper No.38, 2005 (in Japanese).

[13] Itaya, K.; Insights on effective questionnaire-survey approaches toward companies for deeper MOT/Innovation studies. *Abstracts for the Annual Meeting of the Japan Society for Research Policy and Innovation Management*, vol. 31, 2J10, 2016 (in Japanese).

[14] Itaya, K., and Niwa, K.; The moment of serendipity in technology companies: study by participant observation. *International Journal of Environment and Sustainable Development*, vol. 12, no. 1, pp. 72-85, 2013.

[15] Jung, D. I., Chow, C., and Wu, A.; The role of transformational leadership in enhancing organizational innovation: Hypotheses and some

preliminary findings. *The Leadership Quarterly*, vol. 1, pp 525-544, 2003.

[16] Kotilainen, L., Rajalahti, R., Ragasa, C., and Pehu, E.; *Health Enhancing Foods: Opportunities for Strengthening the Sector in Developing Countries.* International Bank for Reconstruction and Development: The World Bank, 2006.

[17] Kubinyi, H.; Chance favors the prepared mind-from serendipity to rational drug design. *Journal of Receptors and Signal Transduction*, vol. 19, no. 1-4, pp. 15-39, 1999.

[18] Mark-Herbert, C.; Innovation of a new product category—functional foods. *Technovation*, vol. 24, no. 9, pp. 713-719, 2004.

[19] Niwa, K.; *Management of Technology*, Tokyo: University of Tokyo Press, 2006 (in Japanese).

[20] Niwa, K., Ishiguro, S., Itaya, K., Shirahada, K., Seino, T., Tezuka, S.; *Practical Study in Management of Technology*, Tokyo, Japan: University of Tokyo Press, 2013 (in Japanese).

[21] Pelz, D. C., and Andrews, F. M.; Scientists in organization: Productive climates for research and development. New York: Wiley, 1966.

[22] Pharmaceutical Research and Manufacturers of America; *Pharmaceutical Industry Profile 2010*. Washington DC: PhRMA, 2010.

[23] Shamay-Tsoory, S. G., Adler, N., Aharon-Peretz, J., Perry, D., and Mayseless, N. The origins of originality: the neural bases of creative thinking and originality. *Neuropsychologia*, vol. 49, no.2, pp. 178-185, 2011.

[24] Siró, I., Kapolna, E., Kapolna, B., and Lugasi, A.; Functional food. Product development, marketing and consumer acceptance—A review. *Appetite*, vol. 51, no. 3, pp. 456-467, 2008.

[25] Thagaard, T.; Research environment, motivation and publication productivity. *Science Studies*, vol. 4, no. 1, pp. 5-18, 1991.

[26] Tierney, P., Farmer, S. M., and Graen, G. B.; An examination of leadership and employee creativity: The relevance of traits and relationships. *Personnel Psychology*, vol. 52, no. 3, pp. 591-620, 1999.

[27] Van Andel, P.; Anatomy of the unsought finding. Serendipity: Orgin, history, domains, traditions, appearances, patterns and programmability. *The British Journal for the Philosophy of Science*, vol. 45, no. 2, pp. 631-648, 1994.

[28] Van Kleef, E., Van Trijp, H. C., Luning, P., and Jongen, W. M.; Consumer-oriented functional food development: how well do functional disciplines reflect the 'voice of the consumer'? *Trends in Food Science & Technology*, vol. 13, no. 3, pp. 93-101, 2002.

[29] Van Kleef, E., Van Trijp, H. C., and Luning, P.; Functional foods: health claim-food product compatibility and the impact of health claim framing on consumer evaluation. *Appetite*, vol. 44, no. 3, pp. 299-308, 2005.

[30] Weisenfeld, U.; Serendipity as a mechanism of change and its potential for explaining change processes. *Management Revue*, vol. 20, no. 2, pp. 138-148, 2009.

[31] Yeh, Y., and Lin, C. F.; Aptitude-treatment interactions during creativity training in E-learning: How meaning-making, self-regulation, and knowledge management influence creativity. *Educational Technology & Society*, vol. 18, no.1, pp. 119–131, 2015.