Qualitative Meta-synthesis Techniques for Analysis of Public Opinions for in-depth Study

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Abstract. Public opinions toward social concerns are worth to be noticed for decision makers to undertake any policies and their outcomes. Social psychologists usually undertake a series of investigations to access the interaction underneath the common thinking or actions. The design and statistic processing of the questionnaires always require a lot of manpower. In this paper, two technologies, denoted as CorMap and iView, for qualitative meta-synthesis which aims to acquire and extract assumptions, hypothesis or even just common grounds for further investigation, are applied to a free-association test on social risk.

Keywords: meta-synthesis, word association, qualitative meta-synthesis, CorMap, iView.

1 Introduction

Right image or perception of public feelings or opinions toward a dedicated topic is important for decision makers to formulate policies or take actions. In recent years, emergency management calls for right intervention toward crisis, where the right image of the crisis is the condition. Nowadays more channels have been explored to acquire public opinions especially as Internet enables the emergence of virtual community, e.g. BBS, on-line opinions or surveys, etc. Huge information accumulated drives the tide of data and text mining technologies for structured patterns. On the other hand, social researchers usually undertake a series of investigations to access the interaction mechanisms underneath the common thinking or actions. The design and statistic processing of the questionnaires always require a lot of manpower. Word association test is a very common way to acquire images and perceptions toward some dedicated topics, such as social risk. Questions such as "What comes to mind when you hear (or see) the word....?" are usually proposed to the people. And many Web sites have enabled such tests easier to be accessed and wide opinions to be acquired. Web-based way increases the efficiency of data collection, further helps are still barely required to facilitate the data processing besides traditional ways. In this paper, we apply two qualitative meta-synthesis technologies, CorMap and iView, to a free-association test on social risk. The iView technology helps to detect the main images toward social risk and also help the analysts in word clustering. The CorMap

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technology may then be helpful to expose the community and their concerns. Moreover, both technologies enable the visualization of the whole analytical process, to show how the diverse public opinions from the diverse word association into somewhat structured hypotheses from which to take in-depth studies.

For better understanding, some concepts on qualitative meta-synthesis are addressed.

2 Qualitative Meta-synthesis

The qualitative meta-synthesis technologies addressed in this paper denote to technologies for meta-synthesis approach (MSA) proposed by Chinese system scientist Qian Xuesen (Tsien Hsue Shen) and his colleagues in the early 1990s [1].

2.1 Meta-synthesis System Approach

Since the 1980s, system rethinking tide started from the western world. In China, Qian and his colleagues made a new classification of systems and proposed one concept open complex giant system (OCGS) problems to denote the systems which are the most complicated and then very difficult to be tackled. By Qian's view, reductionism methods did not work well with those OCGS problems, such as economic system, human system, military system and social system, etc., therefore new system approach which is beyond traditional analytical ways is required. OCGS problems may be regarded as unstructured problems in management science or wicked problems in social sciences. Then ideas of approaches to those problems in one area could be adopted in another.

The essential idea of MSA can be simplified as "confident hypothesizing, rigorous validating", i.e. quantitative knowledge arises from qualitative understanding, which reflects the process of knowing and doing in epistemology. While adopting ideas from meta-analysis, MSA itself emphasizes more on synthesis of analytical results or evidences across different disciplines or fields, which is therefore referred as meta-synthesis. It expects to "unite organically the expert group, data, all sorts of information and the computer technology", and "to unite scientific theories of various disciplines and human experience and knowledge" for both qualitative hypothesizing and quantitative validating.

For better understanding of MSA, Qian proposed a concept - Hall of Workshop for Meta-Synthetic Engineering (HWMSE) as a platform for MSA practicing later [2]. The concept of HWMSE reflects the emphasis of utilization of the breaking advances in information technologies to show to harness the *collective knowledge* and *creativity* of diverse technical group experts by synthesizing data, information, models, knowledge, experiences into interdisciplinary problem-solving process for both confident hypothesizing and quantitative validating. We may regard HWMSE is an advanced state of a decision support system (DSS) while humans are elements of HWMSE and play dominant roles even machine systems (traditional DSS) can provide intensive support. It could be sensed that MSA aims to take humans' advantage in qualitative intelligence (cognition or perception) instead of avoiding those people problems such as human's limited capacity in cognition, subjective prejudice and world views, belief in human experts, etc. in practice.

2.2 Types of Meta-synthesis

OCGS problem solving process may go through three types of meta-synthesis, (i) qualitative meta-synthesis; (ii) qualitative-quantitative meta-synthesis; and (iii) meta-synthesis from qualitative knowledge (hypotheses) to quantitative validation based on systems engineering practice [3]. The 1st type, qualitative meta-synthesis, aims to produce assumptions or hypotheses about the unstructured problems, i.e. to expose some qualitative relations or structures of the concerned problems. Computerized tools, such as group support systems (GSS), creativity support systems (CSS) etc. may support qualitative meta-synthesis. The working process of the qualitative meta-synthesis may be achieved by those problem structuring methods which support the third type of meta-synthesis to achieve final validated knowledge via facilitated collective intelligence. If validation works, solution toward the original unstructured problem is gained. If not, new perspectives need to be explored by three kinds of meta-synthesis for another process of problem structuring and solving. Different meta-synthesis needs different supports, which are of some discussions in correspondence with knowledge creating process in Ref. [4].

MSA studies have been undertaken in recent 15 years and more concerns in complexity research also draw attentions to the methodology itself [5]. Figure 1 shows a working process of meta-synthesis practice [6]. Activities at synchronous or asynchronous stages are relatively differentiated in condition of time pressure.

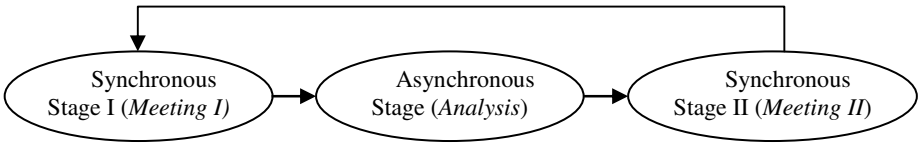

Fig. 1. One Working Process of MSA [6]

Activities held in Synchronous Stage I refer to perspective development or hypothesis generation for meta-synthetic modeling at Asynchronous Stage. Divergent group thinking is the main theme while convergent activities are more required for Synchronous Stage II. Such a working flow serves for better understanding about ideas of MSA by a practical way. It could be understood that a social survey and analysis for social concerns detection also follows such a working process. In Stage I, questionnaires are delivered and answer sheets are then collected after preliminary investigation. After fundamental analysis about variables and impact factors, structure equations may be developed for verification and validation. Larger-scaled investigation will then be undertaken. Thus, a normal process of social investigation of public opinions toward some topics can also be understood as a kind of meta-synthesis practice.

2.3 Meta-synthesis at Different Domains

Meta-synthesis borrows ideas from meta-analysis. In recent 10 years, meta-synthesis is actually a highlighted methodology in qualitative research in comparison to meta-analysis. In qualitative research, how the inquirer finds, evaluates and integrates past

research is important to make meaning of the vast array of studies available on any given topics. Ref. [7-9] addressed the meaning of meta-synthesis, or qualitative meta-synthesis. It can be seen that meta-synthesis of qualitative research is a parallel method or technique to meta-analysis of quantitative research but has important differences. The aim of meta-synthesis is interpretive rather than deductive. "Quantitative meta-analysis aims to increase certainty in cause and effect conclusions, whereas qualitative meta-synthesis seeks to understand and explain phenomena".

It could be seen that in social sciences domain, meta-synthesis is a research methodology to review a large body of literature and systematically synthesize the findings in an effort to develop a more informed understanding of a particular area of interest. Therefore, meta-synthesis referred in social sciences domain mainly denotes qualitative meta-synthesis in systems science where meta-synthesis is as a systemic approach to complex system problem solving. Quantitative modeling is a necessary step, thus studies on the other two types of meta-synthesis are of more endeavors at present.

Whatever, the start of meta-synthesis is firstly to generate hypothesis for further actions including quantitative modeling. It is important to study more methods or supporting technologies to facilitate achieving qualitative meta-synthesis.

3 Qualitative Meta-synthesis Technologies

Ref.[10-11] systematically described two data analysis technologies, CorMap analysis and iView analysis, in the aim of implementing qualitative meta-synthesis for confident hypothesizing. The meta-data for both technologies is with such a structure as

<topic, userID, text, keywords, time>

Such metadata indicates the corresponding *userID* denotes one *text* (e.g. one comment, one blog, the title of a paper, a reply to one question) with a set of *keywords* under the *topic* at the point of *time*. By word segmentation and filtered feature keywords used in text summarization, or even human's identification, a variety of human ideas and opinions can be transferred into one piece of record with that structure. The keywords for a blog may also denote the labels or tags of that blog. The keywords are articulated as attributes of the *userID* or the *text*. Next details of mathematics of both analytical technologies are omitted. Only basic steps are depicted for better understanding.

3.1 CorMap Analysis

CorMap analysis denotes a technology of exploratory analysis of textual data. A general CorMap analysis process is as follows.

Step I. Construct a frequency matrix based on a contingency table of the meta-data.

Two frequency matrices can be generated. The element of one matrix denotes the frequency of keyword i referred by the human j relevant to the topic. The element of another matrix denotes the frequency of keyword i referred by the text $j, i = 1, 2, \ldots, m$, $j = 1, 2, \ldots, n$.

Step II. Conduct correspondence analysis by performing a series of transformations and singular value decomposition (SVD) towards the transformed matrix to acquire the coordinates of both humans (or texts) and keywords which then can be mapped into 2-dimensional or 3D space for visualized analysis.

As a result, a pair of participants with more shared keywords may locate closer in the 2D space.

Step III. Calculate the total inertia of the contingency table to describe the level of association, or dependence between two categorical variables in terms of the singular values and how much that mapping into 2D space accounts for the total variation using the largest two singular values.

As correspondence analysis is only a method for exploratory analysis, the visualized association is not a confirmatory one, and 2 dimensions may not visualize more than 75% of the association between humans and keywords. It is very important to check the value to avoid misuse of the association.

Step IV. Conduct clustering with the spatial relations acquired in Step II. Simply, *k*-means clustering of keywords is usually carried out.

Step V. Calculate the centroid of each cluster and find the keyword which is the closest to the centroid as the label of the cluster.

The above two steps can be done iteratively to see what kind of keyword-grouping is appropriate for ideas clustering and concept extraction for qualitative meta-synthesis.

Step VI. Calculate the right number of clusters based on distortion, which is a measure of with-in cluster dispersion, based on rate distortion theory in the information theory.

A given cluster number may facilitate clustering analysis. Step VI can be taken before Step IV.

The above process shows the essential analytics during CorMap analysis. Such kind of analysis can be applied to any combination of the concerned participants, and may help to "drill down" into those community thoughts to detect some existing or emerging micro community. If applied to an individual user, CorMap analysis may unravel personal thinking structure.

3.2 iView Analysis

Given the same dataset used by CorMap analysis, iView analysis mainly applies network analysis methods to depict the scenario of the topic. The iView analysis is based on the construction of iView network. A general iView analysis process is as follows.

Step I. Construct iView network. The iView network mainly includes 3 kinds of networks, keyword network, human network and text network.

In a keyword network for iView analysis, the link between the vertices (keywords) denotes the co-occurrence of keywords among all texts or humans. Such a network is referred as an *idea map* contributed by all participants. This topological network is a weighted undirected network where the weight of edge denotes the frequency of co-keywords.

In a human network, the link between vertices denotes keywords-sharing between participants. The strength between two participants indicates the number of the different keywords or the total frequencies of all the keywords they share.

There are 3 types of text networks for iView analysis. All are directed networks. Type I text network denotes the directed link from text *j* to text *i* indicating a kind of citing the keyword which originally appears in text *i*. In Type II text network, the link denotes to cite the closest text including the concerned keyword. In Type III text network, the semantic meaning of link expands to a variety of attitudes, e.g. oppose, support, etc. besides the citation of keywords in both Type I & II text networks. Text network may help to show how the ideas grow and spread.

Step II. Conduct a variety of network analysis to acquire the characteristics of iView networks. The basic analyses usually include cutpoint, centrality (degree and betweenness), etc.

A variety of network analysis aims to get more senses, such as expose different perspectives of a collective vision of all the community or the powerful people by centrality analysis, etc. The underlying mathematics applied is mainly from graph theory and social network analysis (SNA).

Step III. Conduct clustering of nodes in the iView network for detection of network structure.

With use of community structure detection methods, clustering of keywords of iView's idea map may help to understand the major points from those keyword clusters easier instead only by frequencies of individual keywords.

Step IV. Assign a label to each cluster. Several ways may be tried. Select the vertex with maximum centrality of degree or betweenness in that cluster. If the weight of links is considered, differences may happen even with one kind of measure of centrality of nodes.

Step V. Visualize the network and various analytical results.

The last step may happen after each previous step.

The pair of idea map and human net could be regarded as one kind of structure about the dedicated topic. The exploited network analysis aims to detect basic concepts and main themes, influential people and the potential micro communities emerged. The information could be regarded as the constructs of the concerned topic and may be helpful to quickly get a rough understanding of the interesting topic or a consensus of the existing community. Actully either idea map or human network is the one-mode projection (such as the sharing keyword between humans) of an original bi-partite network.

It should be indicated that some different algorithms will be applied to Type III text network due to the different semantic meanings of the link at that text network. In this paper, text network is not used in the analysis of the public opinions, thus detailed analytical mechanism of text network is omitted.

3.3 Features of both CorMap and iView Analysis for Qualitative Meta-synthesis

Either CorMap or iView analysis shows different perspectives toward same set of data based on different mechanisms with the same aim to acquire constructs of the

problems from those textual data for one topic. Both analytical technologies share common features:

- By a variety of transformations of original textural data sets to expose the hidden structure;
- Visualization of analyzing process to facilitate human's understanding;
- Adoption of a series of algorithms or methods instead of application of one individual one;.
- Exhibition of support for a problem structuring process. Firstly, give a rough imagine of the issue; secondly, draw a scenario of the issue using clustering analysis to detect the structure; meanwhile, an optimal of clusters is achieved; thirdly, extract concepts from clusters of ideas. Thus, a category of concepts instead of a mess of diverse ideas is acquired step by step;
- Facilitation of human-machine collaboration. Each step leaves rooms to facilitate analysts' direct manipulations and results' visualization.

We can apply both technologies to qualitative meta-synthesis to wicked problems. Due to different mechanism of each technology, one may be more effective to human's understanding at one time. It is human's duty to make appropriate use of each technology during the discovery process.

Next we apply both technologies to a word-association test in social risk.

4 Applying iView and CorMap to Analysis of Word Association for Social Risks

The dataset analyzed here is from a test of word association social risk taken by social psychology researchers from Institute of Psychology, Chinese Academy of Sciences in the 2nd half year of 2007. The sample size for analysis is 321. The age, education, gender and profession of each subject are recorded besides his (her) word association list.

4.1 Collective Image on Social Risk by iView Analysis

In parallel to psychology researcher's normal data processing in word association, we firstly apply iView analysis to the same dataset.

Fig. 2 shows the iView's keyword network of the original dataset with a total of 585 different words contributed by 321 people based a specific iView analysis tool implemented by Research Group on Meta-synthesis and Knowledge Science at the Institute of Systems Science, Chinese Academy of Sciences. Clustering of words is also done.

It is very difficult to recognize the picture as shown in Fig.2 without the enlargement of the image. While with no visualization, analysis of networks can also be undertaken. By network analysis, 58 cutpoint words are detected from 585-word iView idea map. Those cutpoints include words and phrases such as "corruption", "crime", "culture revolution", "disease", "earthquake", "education", "emergency", "fake medicine", "housing problem", "moral hazard", "Olympic Games", "prices of goods", "real estate", "reform and openness", "rich-poor gap", "SARS", "stock",

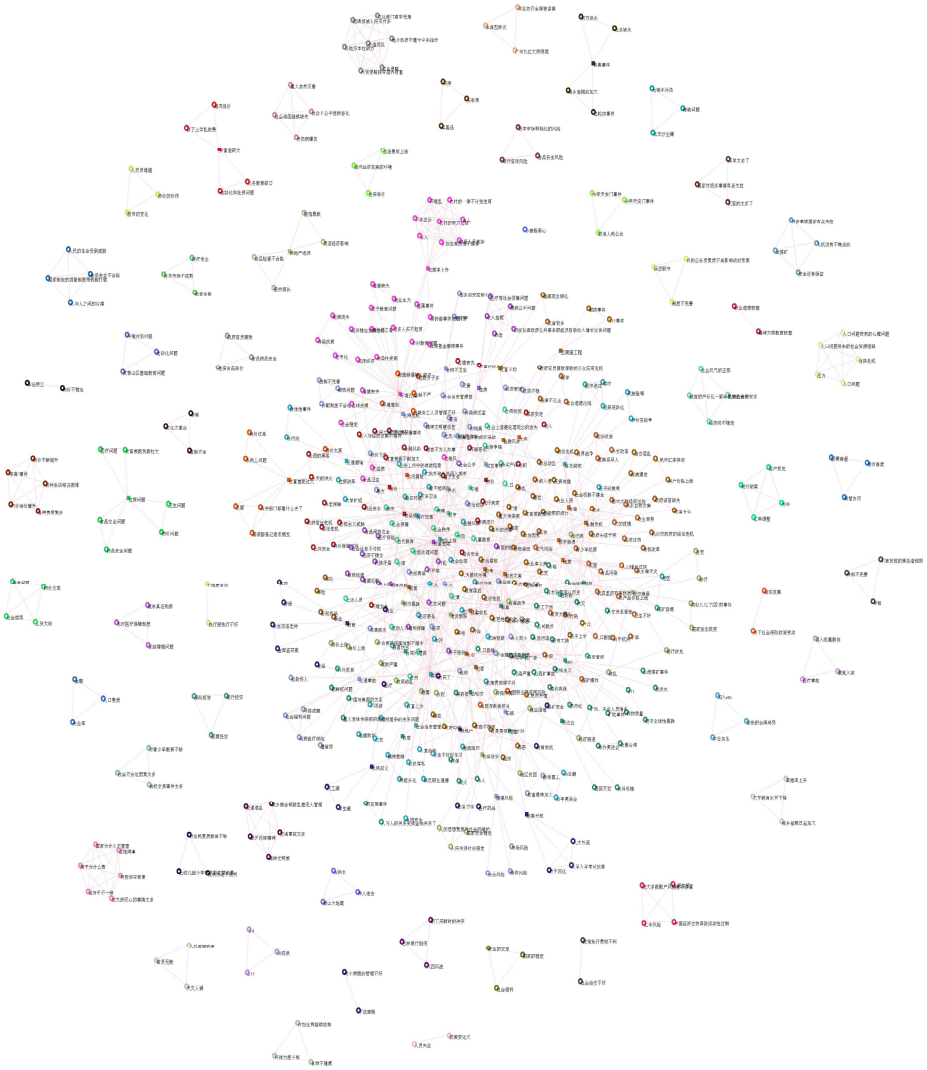

Fig. 2. Image map by iView's keyword network with 65 clusters (Modularity measure Q=0.8127)

"stock market crash", "Taiwan independence", "Taiwan Strait crisis", "traffic jam", "war", etc. In a social network, a cutpoint indicates an information broker. In the idea map, we suppose the cutpoint may indicate an important concept which comes from collective imagine generated by free word association. Those cutpoint words may not be high- frequency words, which are of more concerns at the normal analysis of word association in social psychology study.

Since many synonym words or different sayings toward the same event exist, we suggest the social researchers to deal with those synonym words to decrease the whole

number of different words before they make a category of those words. That can also be helpful for more clear visualization of the network. Secondly, they may consider around 60-70 category of all those words according to the structure detection of keyword network as the highest value for the modularity measure is 0.8167 for 65 clusters. The CorMap analysis was not carried out before preprocessing of synonym words.

While the social researchers gave the coded datasets directly instead dealing with synonyms. Coding means the variables are classified into categories manually. The ages are classified into 4 groups, below 24, between 25 and 29, between 30 and 49 and above 50. The professions include students, business employees, government employees and retired people. All words and phrases are also classified into 30 categories, instead of our suggested size by iView analysis, such as to put "SARS" into a category of "major infectious disease", put sayings such as "traffic jam" into a category of "traffic problem", put "stocks" and "stock market crash" into the category of "financial issues", etc. Then CorMap analysis is carried out toward the different categorized datasets for different purposes.

4.2 Different Images or Perceptions among the Public by CorMap Analysis

Ref. [12] depicts a general data processing toward word association test in social psychology, where word frequency is used to show the extent of concerns. Given the coded datasets, CorMap analysis is applied to study people at different categories (age or profession) and their social risk perception, a totally different way of data processing.

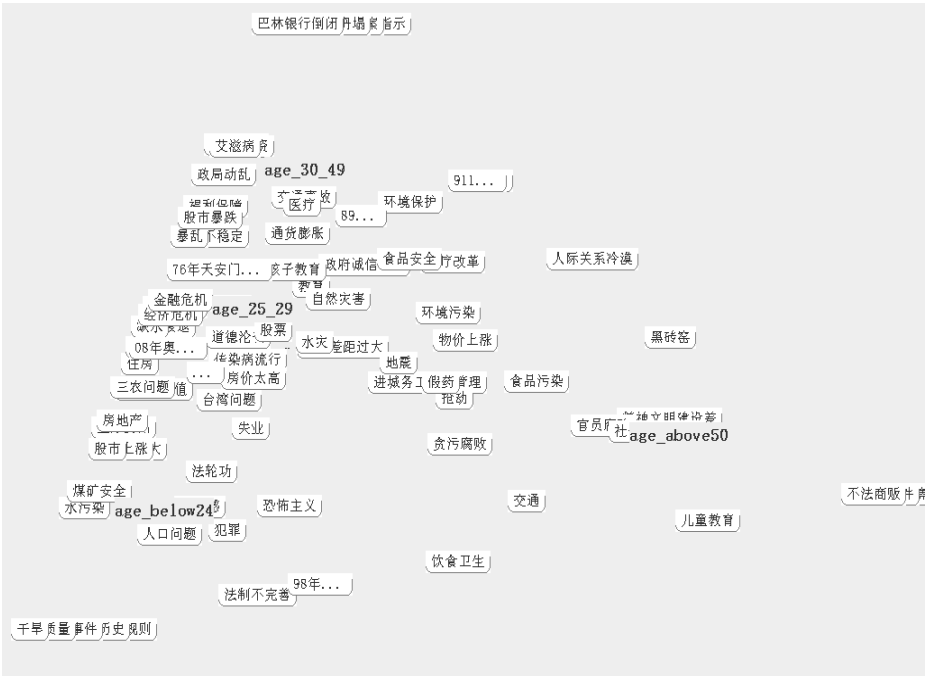

Fig. 3. CorMap of the people at different ages and their words association in social risks

Fig.3 shows a CorMap image of people at different ages and their original words (not the categorized words). In Fig.3's CorMap, the label of category of "age_above50" locates at the right side, far away from those of the other three age categories. As the mapping to 2D space accounts 100% of the total variation, 2D spatial relations are reliable and the distances between those categories indicate the differences of perceptions toward social risks between the public at different ages. The CorMap provides a basic or possible association between the subjects and their thoughts represented by those 217 words. Due to limited visualized spaces, many words are overlapped in the graph.

Next *k*-means clustering is conducted while the right cluster number is 9. Fig.4 is the visualized clustering results with the bigger-font-size word as the labels of each cluster. A list of words in each cluster will pop up to help users check the details.

If not satisfied with the clustering results, trials can be taken again. For example, we may select the second appropriate number 7 or the third candidate 5 as the cluster number. The result is as shown in Fig.5.

Words in different colors indicate that they belong to different clusters. Clustering of words shown here depends on the spatial distance driven from the correspondence mapping. Next the CorMap analysis is shown with the categorized words. Fig.6 is the people at different ages and their words association in social risks.

Since there are only 30 categories of words which means only 30 keywords appear among all data records, the relevance mapping shown in Fig.3 and Fig. 6 are different. We can see that "age_above50" is still far away from the other three groups. Both categories "age_30_39" and "age_25_29" are adjacent in Fig.3, while they locate

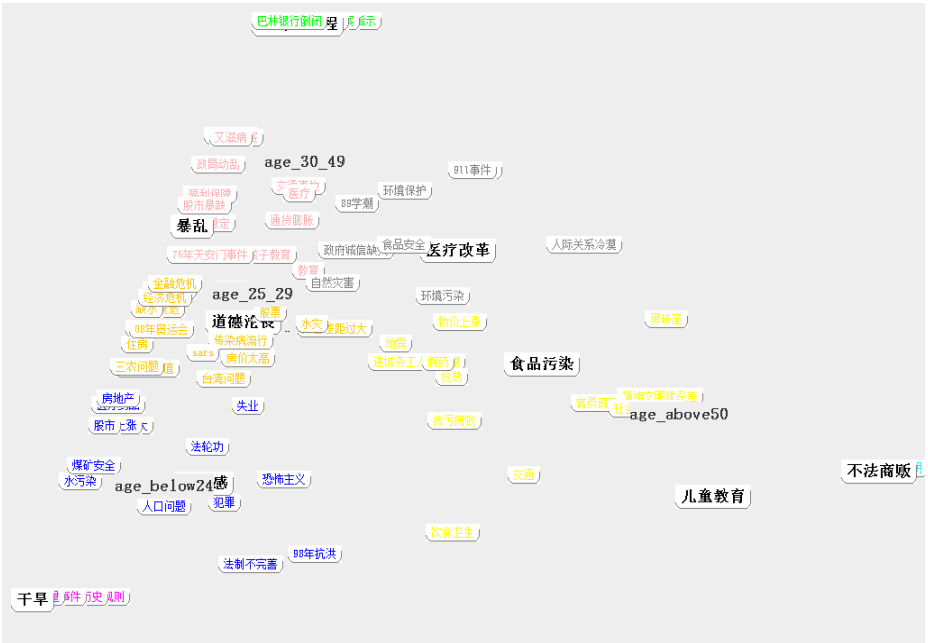

Fig. 4. Clustering of words at a CorMap (9 clusters)

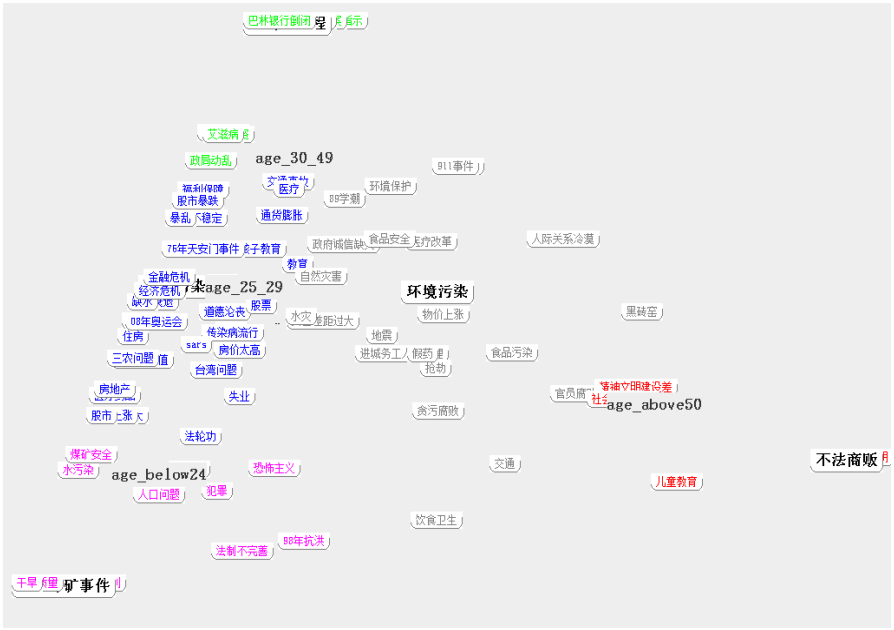

Fig. 5. Clustering of words at a CorMap (5 clusters)

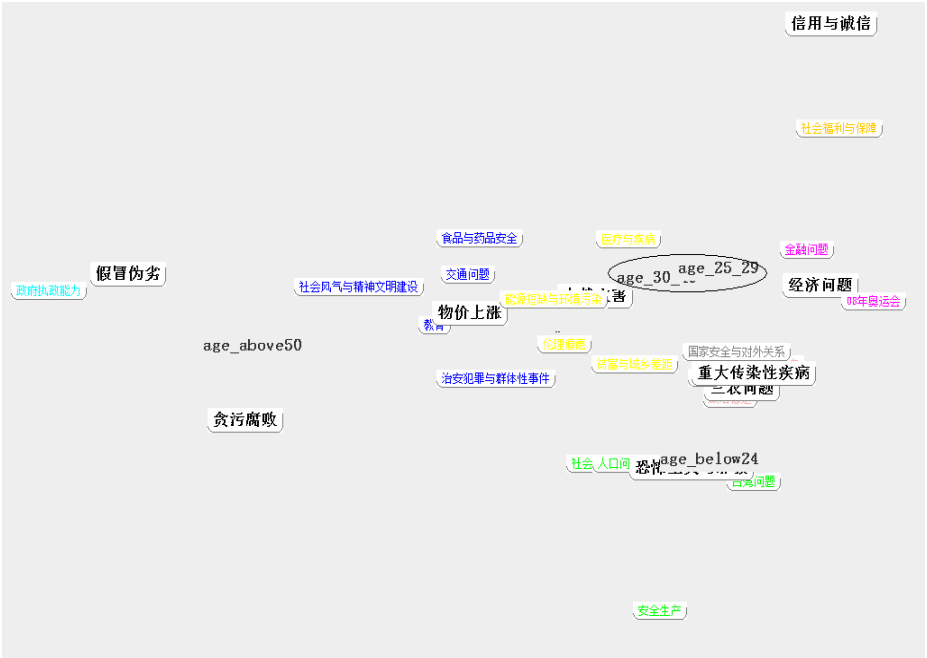

Fig. 6. CorMap of the people at different ages and their words association in social risks (9 clusters of words)

much closer in Fig. 6. The youngest and the oldest are far away at both CorMaps. The mapping to 2D space still accounts 100% of the total variation. Fig.7 is clustering result with one smaller cluster number 4.

Going through the CorMap analysis process, more qualitative senses of social concerns by people at different ages may be made. Both Figures 8 and 9 show the CorMap analysis of the people with different professions and their social concerns. The labels for 4 professions in the figures are 学生 (students), 公司职员 (business employees), 离退休人员 (retired people) and 政府公务员 (governmental employees). The measures of mapping into 2D all reach to 100%. In Fig.8, the "governmental employees" locating in the central area infers their more comprehensive image toward social risks than people from the other three professions. Obviously, "students", "business employees" and "retired people" share fewer concerns of social risks. In Fig. 9, "business employees" and "governmental employees" locate so close that indicates they share more common concerns as the words are categorized into 30 groups. Even with the decrease of number of words, "students" and "retired people" still locate far away in Fig. 9.

Those CorMap graphs clearly show that people working for business and government share closer concerns, while students and retired people hold specific social foci respectively. Those seem to be common sense while the CorMap analysis clearly shows the exact reality. By this point, the visualized CorMap may help the social researchers or even policy makers to quickly understand not only the gaps between people at different ages and professions but the specific concerns by CorMap clustering results as well.

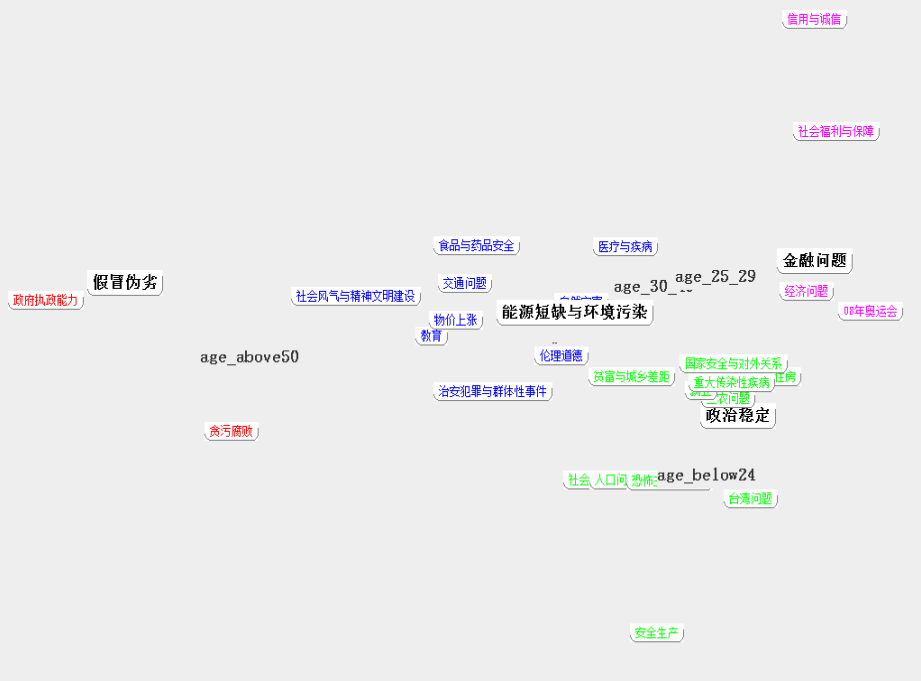

Fig. 7. CorMap of the people at different ages and their words association in social risks (4 clusters of words while all words are of 30 categories)

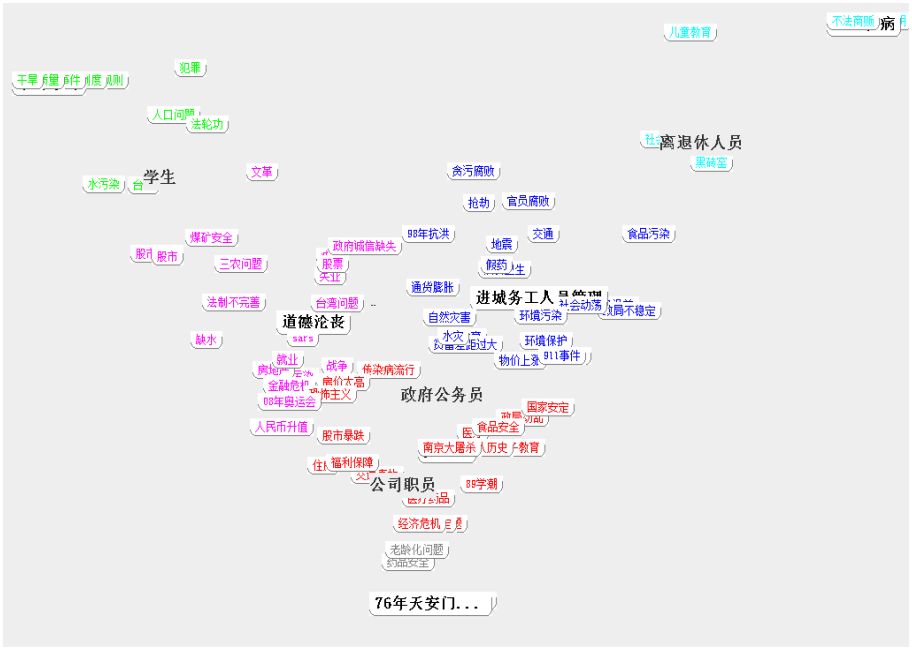

Fig. 8. CorMap of the people at different professions and their words association in social risks (6 clusters of words)

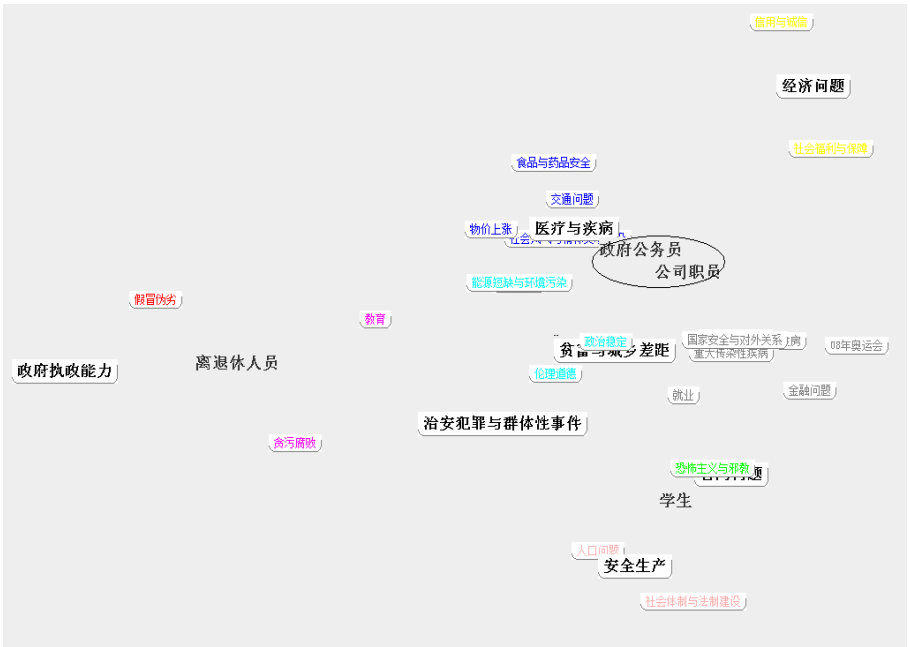

Fig. 9. CorMap of the people at different professions and their words association in social risks (8 clusters of words while all words are from 30 categories)

No further iView analysis is taken after the coding of original dataset. In this word-association test on social risks, CorMap analysis seems more useful than iView analysis to the social analysts for their in-depth study such as constructing a structure equation of social risk and next-round investigations of larger size of involved participants for the verification and validation of the structure equations.

5 Concluding Remarks

In this paper, we address two technologies CorMap analysis and iView analysis for qualitative meta-synthesis which aims to help to produce assumptions or hypotheses about the unstructured problems, i.e. to expose some qualitative relations or structures of the concerned unstructured problems. Either CorMap analysis or iView analysis refers to integration of a series of methods or algorithms instead of an individual method. That is why we do not say CorMap is a statistic method as correspondence analysis, or iView analysis belongs to social network analysis. The main reason is that the motive of either technology is different from those traditional analytical methods.

Both CorMap and iView technologies are applied to analysis of a word association test on social risks taken in 2007. Even those results are still qualitative, more information is acquired beyond general analysis about word association test in social psychology and provides more help for qualitative-quantitative meta-synthesis, such as constructing structure equations of social risks. As both technologies deal with text data, instead of numerical data, we may say they are textual computing technologies and exhibit different results from those traditional individual statistical methods and then help the social researchers to get more senses when exploring the relevance between those possible factors of social risks.

It is a pity that further help to automatic coding of original datasets so as to decrease the work load of the analysts did not work as expected. Even one credo of meta-synthesis system approach is "man-machine collaboration while humans are dominant", we never stop to explore augmented technologies to help human beings to save more energy in information filtering and then reach to the concerned points as effectively as possible. That is the aim of qualitative meta-synthesis technologies.

Either technology can be used individually based on different problems. We had already integrated two technologies into different implementations for different purposes. One is a computerized tool titled TCM Master Miner to do perspective analysis of the thoughts of traditional Chinese medicine masters. TCM Master Miner aims to help people to acquire basic scenario of TCM about the working body of human beings easier and extract the essential TCM masters' essential experiences accumulated during long practice [10]. Another application is an expert discussion system which is developed to facilitate experts' interaction, idea generation during general expert meetings for business planning. During the experts' opinion aggregating process, the dynamic visualization of the opinions by CorMap analysis and iView analysis may help to stimulate active association and feedback as a catalyst for shared understanding and wider thinking. At that specifically designed platform for expert discussion under a spontaneous and free-flowing divergent thinking mode, possible helps provided by both qualitative meta-synthesis technologies are pushed for participants' awareness, even those hints are not confirmatory. Wild ideas toward the dynamic

relevance, especially those isolated ideas far away from the majority may lead to some in-depth investigation for curiosity. At this point, we say both qualitative meta-synthesis technologies serve as one kind of creativity support.

As a matter of fact, public opinions expressed by word association may also be regarded as one kind of community divergent thinking process. Then it is worth applying CorMap and iView analysis to the explorations of perceptions or imagines of the public concerns during some time. In the word association study shown in this paper, we also pay attention to the explanation capacity of 2D CorMap images of the whole datasets instead of ignoring it in the study of divergent group thinking and creativity support. It is really surprised that the explanation capacity of all CorMap images reaches 100%. The coding of the original datasets may be one reason.

It is the first time to take such kind of analysis toward traditional social psychology investigations. Due to the original purposes of both technologies, such kind of application seems to be quite fit for the study. Currently, Internet enables easy access to Web-based word association or other social psychology tests where the size of participants is increasing. It is worth trying new methods and technologies to study those textual data, even the public opinions expressed at a variety of BBS and forums. Good results shown in this paper may indicate more practice of qualitative meta-synthesis technologies in the future.

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