

HOW TO DO A BETTER Q-METHODOLOGICAL RESEARCH: A NEURAL NETWORK METHOD FOR MORE TARGETED DECISION MAKING ABOUT THE FACTORS INFLUENCING Q-STUDY

Mr Amir Eghbalighazijahani
PhD Student
School of the Built Environment, University of Ulster, UK

Professor Julian Hine
Professor of Transport, Translink Chair of Transport
School of the Built Environment, University of Ulster, UK

Dr Anil Kashyap
Lecturer
School of the Built Environment, University of Ulster, UK

Abstract

After more than 75 years of developing Q-Methodology as a method for attitude clustering, still there is a lack of knowledge about the relationship between different variables including the number of statements and participants, total explained variance of study, and finally the number of factors. Different and sometimes inconsistent suggestions have been made on doing Q-methodological research. The aim of this research is to find the relationship between different variables and their influence on the results of Q-study. A numerical method has been developed using the Q Factor Analysis within Matlab programming language to generate 11400 samples by giving different values to the variables. These samples then were analysed by employing linear regression, non-linear regression and neural network methods. The results showed that the average Spearman's ρ of Q sorts has a significant effect on the results of the analysis particularly on the number of factors. The study also showed that the neural network method algorithm with R^2 value of 0.999 has more accurate results in predicting the different variables in comparison with the regression method with R^2 value of about 0.73. Then the non-linear multivariate regression equation was obtained from the neural network output. This equation was used to find the average Spearman's ρ coefficients of 37 Q studies carried out in different fields. The results showed that the level of consensus among participants is strongly negatively correlated with the total number of extracted factors. It was also turned out that the explained variance, number of statements and number of participants are also correlated with the number of factors. Hence, instead of suggesting a fixed number or a range of numbers of participants in the initial stage of the research, we suggest to consider the level of agreement among the potential participants using the materials required to generate the Q-sample.

Key Words: Q-Methodology, factor analysis, Matlab, Neural Network

1- Introduction: what is Q-Methodology?

Q-methodology is an approach that systematically studies the subjectivity [1, 2]. Developed in the 1930s, this method combines the strengths of both quantitative and qualitative approaches [3]. Q provides researcher with in-depth understanding of the attitudes of a particular sector of society to a subject of interest to them and describes the different opinions, viewpoints, beliefs and attitudes held by different respondents [3, 4]. Unlike the R-Methodology, Q is not a method for correlating between variables; rather it correlates the viewpoints to extract the different segments of subjectivity among stakeholders [5]. In a simple word, Q finds the main attitudes (known as factors) among stakeholders, compares them and explains the differences between the supporters of one attitude with supporters of another attitude. According to Exel and Graaf [6, p.3], "*an important notion behind Q methodology is that only a limited number of distinct viewpoints exist on any topic ... [and] any well-structured Q sample, containing the wide range of existing opinions on the topic, will reveal these perspectives*".

In order to conduct a Q methodological research, participants of Q (P-set) are presented with a sample of statements (Q-sample or Q-set) about the topic of study and then are asked to sort-order (Q sort) these statements based on their own perspectives, opinions and interests [7]. Since it has been assumed that small number of items can be found in the extremes,

compliant with the ranking nature of the data in Q methodology. Spearman's rho gives +1 when two 'ranked variables' are completely same (even when the origin data are not) [17]. The first question that may arise here is that, in addition to NS, NP and Var, how Spearman's rho of Q sorts can change NF? This research addresses this question using the data generated by Matlab programming language. It is obvious that the clarifying the relationship between five above mentioned variables in Q methodology can provide Q-researchers with a solid background in designing a better research plan. Particularly, finding this relationship can guide researchers in estimating the number of participants. This paper addresses the following questions:

- 1- Does average Spearman's rho of Q sorts have impact on the number of extracted factors?
- 2- How is the relationship between independent variables (NS, NP, Var, ρ) and dependant variable (NF)? And;
- 3- Drawing upon this relationship, what suggestions can be made to make a better decision about the number of participants (NP) in a Q study?

In order to generate the required data in addressing the above questions, a Matlab program was written. This program takes 4 independent parameters (NS, NP, Var, ρ) as input and by using the Q-Factor analysis, calculates NF as output. Results of this program were evaluated with the results of PQ Method software (version 2.32)^j. 11400 samples (15x19x5x8) were generated by altering four independent parameters as follows: 15 for NS (10, 20, ..., 150), 19 for NP (10, 15, ..., 100), 5 for Var (0.1, 0.3, ..., 0.9) and 8 for ρ (0.1, 0.2, ..., 0.8). Each sample is the average of 50 same calculations. The generated data in Matlab then was exported to SPSS for regression analysis. Since both linear and non-linear regressions didn't produce an acceptable R² value (see section 4), the data was exported to Matlab's Neural Network Toolbox to compute a non-linear fitting equation for the sample data.

An Artificial Neural Network (ANN) or simply Neural Network (NN) is an intelligent computational model that simulate the information processing of the human brains [18]. The first works on this field were published by McCulloch and Pitts [19] and Hebb [20] that introduced a biological model of the brain function. This method is being used widely in different disciplines since it enables researchers to recognise a pattern or to approximate a function on a set of input and output data without having the explicit rules between them [21].

3- Is Spearman's ρ a significant variable? (Research question 1)

Table 1 shows the correlation coefficients between five variables. As expected, there is no statistically significant correlation between any two of four independent variables. But, all of these variables are significantly correlated with NF as dependant variable. Both Kendall's tau-b and Spearman tests detected this significance too. Increases in NP, NS and Var will increase NF (Pearson>0) and increases in ρ will decrease NF (Pearson<0). This means, if the average Spearman's rho of all Q sorts increases, the total number of extracted factors for constant values of NP, NS and Var would decrease.

Figure 2 shows the relationship between NF and four independent variables in some part of the generated data. Figure 2a illustrates the relationship between ρ and NF when NS=50, NP=20, 30, 40, 50 and Var=0.50. It is obvious from this figure that the increase of average Spearman correlation of Q sorts is accompanied by a decrease in NF. Although involving more participants in the research (NP) produces more factors in the left part of the chart ($\rho<0.5$), it doesn't have a significant impact on NF when $\rho>0.5$. In practice, in a Q Methodological research, we will usually be in the left half side of the figure 2a. Because $\rho>0.5$ means that the Q-sample has not been prepared appropriately and has not had

Table 1: Pearson Correlations between variables

Variable	test	NF	ρ	Var	NS	NP
NF	Pearson Correlation	1	-0.315**	0.667**	0.220**	0.209**
	Sig. (2-tailed)		0.000	0.000	0.000	0.000
ρ	Pearson Correlation	-0.315**	1	0.000	0.000	0.000
	Sig. (2-tailed)	0.000		1.000	1.000	1.000
Var	Pearson Correlation	0.667**	0.000	1	0.000	0.000
	Sig. (2-tailed)	0.000	1.000		1.000	1.000
NS	Pearson Correlation	0.220**	0.000	0.000	1	0.000
	Sig. (2-tailed)	0.000	1.000	1.000		1.000
NP	Pearson Correlation	0.209**	0.000	0.000	0.000	1
	Sig. (2-tailed)	0.000	1.000	1.000	1.000	

** Correlation is significant at the 0.01 level (2-tailed), N=11400

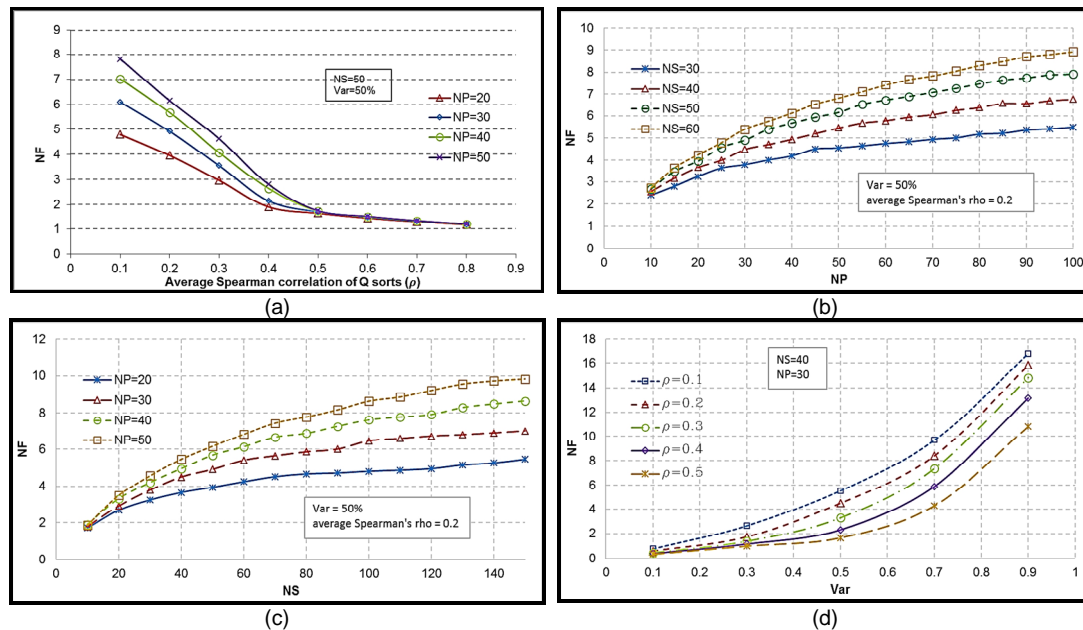


Figure 2: relationship between NF and four independent variables (a) ρ , (b) NP, (c) NS, (d) Var

challenging statements for participants; which is not the case in Q Methodology. It has been strongly suggested by pioneer scholars that researcher should avoid the statements which everyone (or no one) in the participant list likely to agree or disagree with [15]. In the next sections we will see that ρ of different studies is usually between 0.20 and 0.50. One simple function that can fit the diagrams in figure 2a is an exponentially decreasing function.

Although figure 2a clearly answers the first research question, an example can further clarify the issue. Suppose that we have a constant number of statements (NS), sorted by two groups of participants with the same size ($NP_1 = NP_2$), and we are looking for the number of factors (NF) explaining the constant variance of the study ($Var_1 = Var_2$). Although impossible in reality, assume that all of the individuals in the first group have sorted the statement in the same order (average Spearman's $\rho = 1$), and all participants in second group have sorted the statement with different orders with each other (average Spearman's $\rho < 1$). Hence, the analysis of Q sorts of the first group will extract only one factor even when the required explained variance is equal to 100%. But the same analysis for the Q sorts in the second group will extract more than one factor. Thus, there is a significant relationship between 'average Spearman's rho' of Q sorts and NF.

The relationships between NF and NP and also between NF and NS ($Var = 50\%$ and $\rho = 0.2$) have been shown in figures 2b and 2c respectively. As seen from these figures, increasing the number of statements or participants will increase the number of the extracted factors for a constant Var (explained variance). In both charts, relationship is a non-linear equation that can be fitted by a natural logarithmic function with $R^2 > 0.9$. For example, the bottommost diagram ($NS = 30$) in figure 2b can be fitted by $NF = 1.362 \ln(NP) - 0.802$ ($R^2 > 0.99$). Similarly the uppermost diagram ($NS = 50$) in figure 2c can be fitted by $NF = 3.094 \ln(NS) - 5.709$ ($R^2 > 0.99$).

Figure 2d highlights the significant role that explained variance (Var) plays in the number of extracted factors. Each diagram in this figure can be fitted by an exponential function. Hence, deciding to increase the explained variance, will hastily increase the required factors. This figure also makes the sense that why the previous researchers suggest to limit the total explained variance to 50%.

4- How is the relationship between different variables? (Research question 2)

There is significant and non-linear relationship between NF and four independent variables. This can be seen in all plots in figure 2. Therefore, finding a linear equation which properly can fit all of the sample data will not be possible. Linear regression analysis by SPSS software confirms this statement by giving the $R^2 < 0.64$. On the other hand, doing a good non-linear regression (with R^2 near to 1) requires a strong knowledge of the behaviour of each independent variables on the dependant variable as well as the behaviour of each

independent variable on the other independent variables. As shown in Table 1, the correlation between independent variables are zero in this study. Hence it would be sufficient to consider only the behaviour of four independent variables on NF. As discussed above, the relationship between NF and two independent variables in Figures 2a and 2d (ρ and Var) is exponential. Also the relationship between NF and both NS and NP (figures 2b and 2c) is natural logarithmic. Hence, instead of using the values of the independent variables, their corresponding non-linear function were defined and the obtained values were used as independent variables in SPSS to reflect these non-linear relationships. Although the obtained non-linear regression function is better than the linear function, it cannot be used for predicting the number of factors in the future works. Because not only it again didn't reach to an acceptable correlation with the sample data ($R^2=0.678$), but also unclear distribution of the error cannot guaranty that even the function could predict an acceptable and sensible value for NF in a particular study. As an example, sometimes it predicts minus amount for NF (see figure 4). Although combination of all eight variables, which had been used in linear and non-linear regression increased the R^2 value to 0.723, still the issues of unclear distribution of error and small R-squared exist. Hence, the Neural Network method was used to find a better equation that can be fitted to the sample data.

A biological neural network consists of a set of interconnected group of neurons that are used in developing an ANN. Each input or output variable in the data set is modelled by a neuron which sometimes is called "unit". Each unit can take one or more inputs, but it produces only one output. These variables form the "input layer" and "output layer". In fact the "input layer" indicates the information given to a human brain and "output layer" represents the commands that the brain sends out. In order to simulate the functional aspects of the brain in producing the output(s) from input data, another layer(s), known as "hidden layer(s)", is used. The input layer usually is shown by "Layer 0". This numbering continues until the output layers receives the name of "Layer N", where N is the number of the layers in the hidden area added by one. Adding more layers (multi-hidden layer) in hidden area can be beneficial when there is strong non-linear relationship between the input and output data that was not the case in our study. In this study we use $N=2$ (only one hidden layer in hidden area) because we could find an average linear relationship between the input and output variables by linear regression. Also combination of linear and non-linear regressions increased the R^2 value which means that there is not strong non-linear relationship between the input and output variables. The collection of the neurons and their connections is known as Neural Network Architecture (NNA). Various types of NNAs can be found for a given set of input, output and hidden neurons. In this study, the 'feed-forward network' was used. In a feed-forward network each neurons gets its value only from the neurons in the previous layer. Each link (arrow) in the network architecture represents the weight of influence of one neuron in the start of the arrow on the neuron which arrow ends.

Figure 3 shows the Network Architecture used in this study. Input layer consists of four variables (NR, NS, Var, W); output layer has only one variable (NF) and the hidden layer comprises 15 hidden neurons, H1, H2, ..., H15 (intermediate variables). The selection of fifteen hidden neurons in this study which is a large number in comparison to other studies can be justified by considering the need of the research to accurate predictionⁱⁱ. It should be

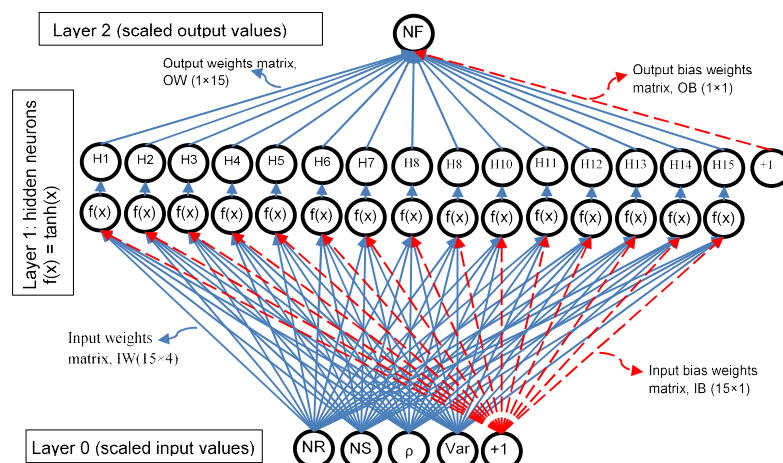


Figure 3: the Neural Network Architecture (NNA) used in this study

mentioned that although neural network approach is able in predicting the output from the input data, it doesn't give a clear explanation of the relationship and this why sometimes this method has been classified within the "black box" category methods [23]. Structural and functional properties of the neurons in the hidden layer(s) are same with the neurons in both input and output layers. As mentioned above, each neuron in our study (in input, output or hidden layer) receives its value only from the neurons in the lower layer. In order to calculate the value for i^{th} neuron in layer p , the perceptron function is used as below:

$$N(i, p) = f\left(\sum_{j=1}^m w_j \cdot N(j, p-1) + b(i, p)\right) \quad (\text{eq. 1})$$

Where:

m : number of the neurons in layer $p-1$,
 w_j : weight of j^{th} neuron in layer $p-1$ on neuron N_i in layer p ,
 $N(j, p-1)$: value of j^{th} neuron in layer $p-1$, and
 $b(i, p)$: bias value of neuron i in layer p .

The function $f(x)$ is known as transfer or activation function. There are different functions that can be used as transfer function (known as sigmoid functions), but according to literature [24, 25], $\tanh(x)$, shown in equation 2 is often the best choice.

$$f(x) = \tanh(x) = \text{tansig}(x) = \frac{2}{1 + e^{-2x}} - 1 \quad (\text{eq. 2})$$

Since the output of the transfer function is a number between -1 and +1, in the first step of the calculation, it is required to scale the values of the input and output neurons in this range to overcome the problem of different magnitudes and units among the variables. Then, computation of the values start from the neurons in the input layer (with the scaled value) by giving the random weights to all arrows in the network architecture (like a new-born baby's brain). The result of this process (from input layer to hidden layer and then from hidden layer to output layer) is the first predicted output matrix which has the same size with the expected output. In the next step, the "backward propagation of errors" algorithm, or simply 'backpropagation' is used to minimise differences between the expected and predicted matrixes by adjusting the weights (training process) [26]. Mean Squared Error (MSE) function is usually used to compare the consistency between two matrixes. This process continues until the error function reach to minimum amount [27]. The general equation used in this study is:

$$Y = OB + OW \times \text{tansig}(IB + IW \times X) \quad (\text{eq. 3})$$

By using the Matlab Neural Network Fitting Tool and doing some algebra, the following non-linear multivariate regression equation was extracted:

$$NF = -3.898 + \begin{pmatrix} 0.066 \\ -37.553 \\ -37.29 \\ -12.525 \\ 16.513 \\ -47.382 \\ -36.829 \\ -15.701 \\ 20.495 \\ 33.16 \\ 0.019 \\ 8.983 \\ -67.361 \\ 16.802 \\ -40.156 \end{pmatrix} \times \text{tansig} \left(\begin{pmatrix} -5.039 \\ -2.515 \\ 3.234 \\ -0.087 \\ 0.887 \\ 0.599 \\ 2.526 \\ -0.125 \\ 3.374 \\ 0.358 \\ -2.387 \\ 3.126 \\ -3.079 \\ -1.202 \\ 3.269 \end{pmatrix} + \begin{pmatrix} 1.151 & 1.426 & -0.845 & -3.122 \\ -1.233 & 2.169 & 1.093 & -0.506 \\ 0.322 & -2.133 & -0.644 & -0.159 \\ 0.666 & -0.56 & 0.358 & 0.261 \\ -1.893 & 2.582 & 0.055 & 0.16 \\ -1.687 & 2.143 & -0.021 & 0.075 \\ 1.181 & -2.257 & -1.086 & 0.46 \\ -0.657 & 0.457 & -0.329 & -0.253 \\ 0.575 & -1.048 & 1.595 & -0.32 \\ -1.542 & 1.821 & -0.102 & 0 \\ -2.389 & -3.56 & 0.559 & -0.648 \\ 0.073 & -1.596 & -1.513 & -0.036 \\ -0.358 & 1.239 & 0.879 & -1.027 \\ -0.752 & 1.082 & 0.327 & 0.127 \\ 0.257 & -1.134 & -1.216 & 1.167 \end{pmatrix} \times \begin{pmatrix} (20r-9)/7 \\ (10Var-5)/4 \\ (NS-80)/70 \\ (NP-55)/45 \end{pmatrix} \right) \quad (\text{eq. 4})$$

Figure 4 shows the excellent consistency between expected and predicted output and compares it with the results of linear and non-linear regressions. It can be concluded that by having four independent variables in hand, the number of factors can be predicted. This equation has been used in the next section to find ρ from known values of NS, NP, NF and Var.

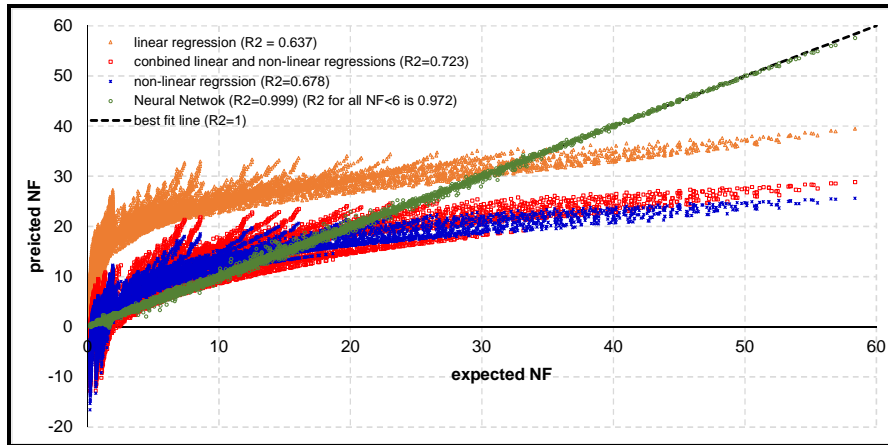


Figure 4: regression coefficients between expected and predicted NF in different methods (N=11400)

5- Suggestions for Q researchers (Research question 3)

This section aims to make some applicable recommendations for deciding about the number of participants. In order to support and compare our suggestions with the reality, 37 peer-reviewed Q studies were reviewed and analysed. Equation 4 was used in order for finding the average Spearman ρ in different studies by coding the Bolzano's Theorem [28, p.216] in Matlab. 51 peer reviewed articles were chosen randomly. 13 articles that had not stated the explained variance or eigenvalues of the factors were excluded from the analysisⁱⁱⁱ. Four articles had mixed the standard Q Methodology with other methods that were removed from the list. 34 Articles remained for analysis [11, 29-60]. Three transport related Q studies were added in later for comparison purposes [13, 61, 62]. Results show that the average Spearman's ρ changes from 0.03 [41] to 0.70 [58]. This means that the topic under investigation is an important factor that directly influences the average Spearman's ρ of the Q-sorts and consequently changes the number of factors (NF) and explained variance (Var). Although ρ changes in a wide range (from 0.03 to 0.70), as shown in figure 5, in 25 (out of 37) article it sits between 0.2 and 0.50. Average ρ between all articles is 0.35 ($\sigma=0.15$). Drawing upon the value of standard deviation of ρ in 37 articles ($\sigma=0.15$), we classified these articles into four groups as shown in figure 5.

Table 2 shows the average of three independent variables in four defined ranges. As expected, total explained variance increases alongside ρ . Except reference [11], all articles in range A have not reached to the acceptable Var=50% even by recruiting a small number of participants. It can be concluded that, in range A, in addition to small number of participants, researchers should reduce the statements as many as possible to conduct a more focused research study in

Table 2: comparison between independent variables in 37 Q-studies in different ρ ranges

Range	N	NP	NS	Var
range A $0.00 < \rho < 0.20$	4	27.25	31	0.46
range B $0.20 < \rho < 0.35$	16	35.75	40.38	0.54
range C $0.35 < \rho < 0.50$	11	39.09	41.91	0.60
range D $0.50 < \rho < 0.70$	6	44	49.83	0.74
All ranges	37	37.16	41.35	0.58

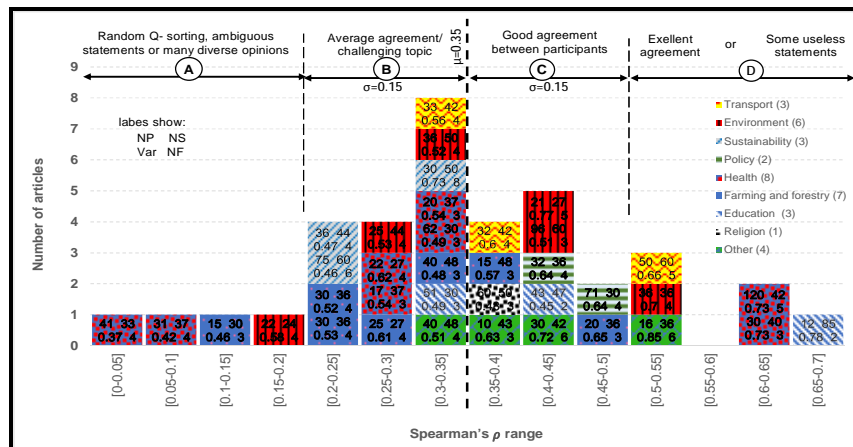


Figure 5: Spearman's ρ value in different Q studies

Table 3: number of participants to explain 50% of variance

p	NF	NS	NP range	p	NF	NS	NP range	p	NF	NS	NP range	p	NF	NS	NP range			
Range A (0.10<p<0.20)	3	20	17-36	Range B (0.20<p<0.35)	3	25	25-90	Range C (0.35<p<0.50)	3	30	62->100	Range D (0.50<p<0.70)	3	35				
		25	11-25			35	15-49			40	41->100			45				
		30	8-19			45	10-36			50	32->100			55				
		40	6-12			65	8-24			70	23->100			75				
	4	20	40-77		4	25	52->100		4	30	>100->100		4	35		4	45	
		25	27-52			35	32->100			40	88->100			45				
		30	21-40			45	23-74			50	65->100			55				
		40	14-27			65	16-48			70	44->100			75				
	5	20	80->100		5	25	91->100		5	30	>100->100		5	35		5	45	
		25	50-91			30	68->100			40	>100->100			45				
		30	37-67			40	46->100			50	>100->100			55				
		40	25-46			65	26-83			70	76->100			75				

order to be able to explain at least 50% of the variance by a reasonable number of factors. It also will be beneficial for researcher double check the clarity and unambiguousness of the statements. Furthermore, as we know, Spearman correlation between two randomly generated data is near to zero. In Q context, this means that there are many diverse opinions on the topic. Hence, when $0 < \rho < 0.20$, it is strongly recommended to validate the results of the study with the results of another semi-quantitative method such as Framework Analysis method [63] or Classical Content Analysis [64] in order to enhance the reliability of the results by scientifically rejecting that participants have not read statements carefully or have not spent sufficient time in Q sorting process. Because even when we ask participants to sort the statements without reading them, we can extract some factors with different eigenvalues greater than 1. That is why Horn introduced the parallel analysis test for deciding about the number of factors in factor analysis [65].

In contrast, articles in range D explain higher amount of variance (averagely 74%). Studies in this range allow researcher to have more statements and recruit more participants to explain an acceptable amount of the variance by small number of factors. Results of the studies in range D are reliable and do not need to be validated by the results of other methods. The only concern for the studies in this range is that in some studies a considerable number of statements are not challenging for participants and hence are not useful for researcher. This issue increases the explained variance deceptively. As an example, although reference [58] does not discuss about the sorting sheet and factor arrays, by using the given Z-scores, it can be calculated that more than 40 percent of the statements in Q sample have been agreed or disagreed with all of the supporters of two extracted factors that is a bit large number even for two factor solution. It should be mentioned again that Q methodology is not a confirmatory method for hypothesis testing. Rather it is a systematic approach for generating typology of attitudes. Hence, researcher should avoid those statements that are likely to be agreed or disagreed with all of the participants. Ranges 'B' and 'C' have intermediate situations in comparison to ranges 'A' and 'D'. Studies in range 'B' are usually about a challenging issue. Similarly to range 'A', we suggest that the results of Q method for studies in range 'B' should be validated by the results of another qualitative or quantitative method. Results of the studies in range 'C' have acceptable reliability. This does not mean that the Spearman's rho is the only criteria for testing the reliability of a given study. The assumption here is that researchers in this range have used unambiguous statements that only few of them have been accepted or rejected by all (or near to all) of the participants. Table 3 shows the number of required participants to explain at least 50% of the variance by 3, 4 and 5 factor solutions.

6- Conclusions

Q methodology is an approach for data reduction as well as data clustering. Regarding the data reduction, it is desired to draw the conclusion from most of the available data and consequently to ignore as little data as possible, therefore increasing the explained variance (Var) is one of the desired aims. Most of the literature has suggested to consider $Var=50\%$ as the minimum acceptable amount which is followed in this work. On the other hand, Q as a data clustering method aims at finding a reasonable number of attitudes (factors) among the participants. The literature showed that 3, 4 or 5 factor solutions are the best choices. The more factors the smaller eigenvalue of each factor i.e. all of extracted factors are not supported by a considerable percent of participants^{iv}. However, these two characteristics (Q as data reduction / clustering method) do not work in the same way i.e. increasing the number of factors reduces the explained variance of the study.

This study does not support the previous studies which claim that the number of participants in a Q study must be less than the number of statements. In fact small numbers of participants could be a concern when researchers were interested to extract 'NP+1'th factor which is not the case in Q methodology since it is a data clustering-reduction method. We believe that as long as researchers can explain an acceptable amount of the variance by a reasonable number of factors, increasing the number of participants can increase the reliability of the research. Because the factors of a Q study revealed from a small number of participants is more sensitive to change by adding another participant to the P-set. Q methodology can be used by small number of participants, however, it does not mean that it is not suitable to be used by large number of participants.

It has been found that there is no clear cut rule to calculate the number of participants since it depends on other variables including NS, Var, expected or desired NF, and the level of consensus between participants about the topic (ρ). Hence, the best suggestion for each research study, with respect to the number of participants, can be made by its researcher. Unfortunately it is not possible to calculate the exact value of ρ before Q sort phase is completed. However, we suggest that researchers can estimate this parameter by considering the materials used for generating the Q set, e.g. interviews and focus group. A simple bell shape sorting chart (maximum 5 columns) can be used to predict the sorting of some percent of participants in a way that the average of Spearman correlation between these ranking data can be used as an estimation for ρ which can be used in determining the number of participants.

Endnote

i Free software, available online at <http://schmolck.userweb.mwn.de/qmethod/#PQMethod>

ii One of the main differences between artificial neural network and brain is related to intelligence issue. Adding more neurons in ANN increases the intelligence of model. But this doesn't necessarily mean that larger brains are more intelligent [22] Roth, G. and U. Dicke, Evolution of the brain and intelligence. Trends in Cognitive Sciences, 2005. 9(5): p. 250-257.

iii It was possible to estimate the explained variance in some of the excluded articles from the loading coefficients of the Q sorts in each factor. But because this could enter a small error (because of using the rounded numbers) in the results, it was preferred to only analyse those articles that had directly mentioned the explained variance of their studies.

iv Also $NF > 5$ will limit the ability of the researcher in rich interpretation about each factor. This is why Brown [1, p.223] suggests to use 'magic number seven' of un-rotated factors. Because after doing a factor rotation a few number of the factors will be removed from the final interpretation. Also, this recommendation has been actioned by developers of the most popular software in the field, PQ Method.

7- References

- [1] Brown, S.R., A primer on Q methodology. Operant subjectivity, 1993. 16(3/4): p. 91-138.
- [2] Brown, S.R., Q methodology and qualitative research. Qualitative health research, 1996. 6(4): p. 561-567.
- [3] Stephenson, W., Correlating persons instead of tests. Journal of Personality, 1935. 4(1): p. 17-24.
- [4] Brown, S.R., Political subjectivity: applications of Q methodology in political science. 1980: Yale University Press.
- [5] Akram, W., J. Hine, and J. Berry. Transport governance, structures and policy implementation: A methodological framework. in Irish Transport Research Network 2011 (ITRN 2011). 2011. Cork, Republic of Ireland.
- [6] Exel, J. and G. Graaf, Q methodology: A sneak preview. Online document. qmethodology. net/PDF/Q-methodology, 2005.
- [7] De Graaf, G. and J. Van Exel, Using Q methodology in administrative ethics. Public Integrity, 2008. 11(1): p. 63-78.
- [8] Dziopa, F. and K. Ahern, A systematic literature review of the applications of Q-technique and its methodology. Methodology: European Journal of Research Methods for the Behavioral and Social Sciences, 2011. 7(2): p. 39.
- [9] Chinnis, A.S., D.J. Paulson, and S.M. Davis, Using Q methodology to assess the needs of Emergency Medicine support staff employees. The Journal of Emergency Medicine, 2001. 20(2): p. 197-203.
- [10] Watts, S. and P. Stenner, Doing Q methodology: theory, method and interpretation. Qualitative Research in Psychology, 2005. 2(1): p. 67-91.
- [11] Hall, C. and A. Wreford, Adaptation to climate change: the attitudes of stakeholders in the livestock industry. Mitigation and Adaptation Strategies for Global Change, 2012. 17(2): p. 207-222.
- [12] Watts, S. and P. Stenner, Doing Q Methodological Research: Theory, Method & Interpretation. 2012: SAGE Publications.
- [13] Rajé, F., Using Q methodology to develop more perceptive insights on transport and social inclusion. Transport Policy, 2007. 14(6): p. 467-477.

- [14] Barry, J. and J. Proops, Seeking sustainability discourses with Q methodology. *Ecological Economics*, 1999. 28(3): p. 337-345.
- [15] Donner, J.C., Using q-sorts in participatory processes: An introduction to the methodology. *Social Development Papers*, 2001. 36: p. 24-49.
- [16] Valenta, A.L. and U. Wigger, Q-methodology: Definition and application in health care informatics. *Journal of the American Medical Informatics Association*, 1997. 4(6): p. 501-510.
- [17] Howell, D.C., *Statistical Methods for Psychology*, 8th ed. 2011: Wadsworth Cengage Learning.
- [18] Flores, J.A., *Focus on Artificial Neural Networks*. 2011: Nova Science Publishers, Incorporated.
- [19] McCulloch, W. and W. Pitts, A logical calculus of the ideas immanent in nervous activity. *The bulletin of mathematical biophysics*, 1943. 5(4): p. 115-133.
- [20] Hebb, D.O., *The Organization of Behavior: A Neuropsychological Theory*. 1949, 2002: Taylor & Francis.
- [21] Tu, J.V., Advantages and disadvantages of using artificial neural networks versus logistic regression for predicting medical outcomes. *Journal of Clinical Epidemiology*, 1996. 49(11): p. 1225-31.
- [22] Roth, G. and U. Dicke, Evolution of the brain and intelligence. *Trends in Cognitive Sciences*, 2005. 9(5): p. 250-257.
- [23] Lee, C., et al., Structured neural network techniques for modeling loyalty and profitability. *Proceedings of SAS User Group International (SUGI 30)*, 2005: p. 082-30.
- [24] Depenau, J., Automated Design of Neural Network Architecture for Classification, in *DAIMI, Computer Science Department 1995*, Aarhus University: Aarhus.
- [25] Karlik, B. and A.V. Olgac, Performance analysis of various activation functions in generalized MLP architectures of neural networks. *International Journal of Artificial Intelligence and Expert Systems*, 2011. 1(4): p. 111-122.
- [26] Fausett, L.V., *Fundamentals of Neural Networks: Architectures, Algorithms, and Applications*. 1994: Prentice Hall International.
- [27] Ripley, B.D., *Pattern Recognition and Neural Networks*. 2007: Cambridge University Press.
- [28] Eriksson, K., D. Estep, and C. Johnson, *Applied Mathematics: Body and Soul: Volume 1: Derivatives and Geometry in IR3*. 2004: Springer.
- [29] Frantzi, S., N.T. Carter, and J.C. Lovett, Exploring discourses on international environmental regime effectiveness with Q methodology: A case study of the Mediterranean Action Plan. *Journal of Environmental Management*, 2009. 90(1): p. 177-186.
- [30] Cuppen, E., et al., Q methodology to select participants for a stakeholder dialogue on energy options from biomass in the Netherlands. *Ecological Economics*, 2010. 69(3): p. 579-591.
- [31] Ockwell, D., 'Opening up' policy to reflexive appraisal: a role for Q Methodology? A case study of fire management in Cape York, Australia. *Policy Sciences*, 2008. 41(4): p. 263-292.
- [32] Mbeng, L.O., P.S. Phillips, and R. Fairweather, Developing sustainable waste management practice: application of Q methodology to construct new strategy component in Limbe-Cameroon. *The Open Waste Management Journal*, 2009. 2: p. 27-36.
- [33] Gruber, J.S., Key principles of community-based natural resource management: a synthesis and interpretation of identified effective approaches for managing the commons. *Environmental management*, 2010. 45(1): p. 52-66.
- [34] Rodriguez-Piñeros, S., et al., Incorporating Values into Community-Scale Sustainable Forest Management Plans: An Application of Q Methodology. *Small-Scale Forestry*, 2012. 11(2): p. 167-183.
- [35] Hermans, F., et al., Assessing Sustainability Perspectives in Rural Innovation Projects Using Q-Methodology. *Sociologia Ruralis*, 2012. 52(1): p. 70-91.
- [36] Buckley, C., Implementation of the EU Nitrates Directive in the Republic of Ireland — A view from the farm. *Ecological Economics*, 2012. 78(0): p. 29-36.
- [37] Asah, S.T., et al., Diagnostic reframing of intractable environmental problems: Case of a contested multiparty public land-use conflict. *Journal of Environmental Management*, 2012. 108(0): p. 108-119.
- [38] Urquhart, J., P. Courtney, and B. Slee, Private woodland owners' perspectives on multifunctionality in English woodlands. *Journal of Rural Studies*, 2012. 28(1): p. 95-106.
- [39] Bouwman, H., A. Bejar, and S. Nikou, Mobile services put in context: A Q-sort analysis. *Telematics and Informatics*, 2012. 29(1): p. 66-81.
- [40] Jepson, W., C. Brannstrom, and N. Persons, "We Don't Take the Pledge": Environmentalism and environmental skepticism at the epicenter of US wind energy development. *Geoforum*, 2012. 43(4): p. 851-863.
- [41] Sung, K., Exploring Wisdom in the Korean Elderly: A Q Methodology Study.

- Asian Nursing Research, 2011. 5(2): p. 128-140.
- [42] Malia, C. and M.I. Bennett, What Influences Patients' Decisions on Artificial Hydration at the End of Life? A Q-Methodology Study. *Journal of Pain and Symptom Management*, 2011. 42(2): p. 192-201.
- [43] Kristensen, E. and E.B. Jakobsen, Danish dairy farmers' perception of biosecurity. *Preventive Veterinary Medicine*, 2011. 99(2-4): p. 122-129.
- [44] Bryant, L.D., et al., 'All is done by Allah'. Understandings of Down syndrome and prenatal testing in Pakistan. *Social Science & Medicine*, 2011. 72(8): p. 1393-1399.
- [45] Diseth, R.R., K.-P. Bøgwald, and P.A. Høglend, Attitudes among stakeholders towards compulsory mental health care in Norway. *International Journal of Law and Psychiatry*, 2011. 34(1): p. 1-6.
- [46] Yeun, E., Attitudes of elderly Korean patients toward death and dying: an application of Q-methodology. *International Journal of Nursing Studies*, 2005. 42(8): p. 871-880.
- [47] Lansing, D.M., Not all baselines are created equal: A Q methodology analysis of stakeholder perspectives of additionality in a carbon forestry offset project in Costa Rica. *Global Environmental Change*, 2013. 23(3): p. 654-663.
- [48] Duenckmann, F., The village in the mind: Applying Q-methodology to reconstructing constructions of rurality. *Journal of Rural Studies*, 2010. 26(3): p. 284-295.
- [49] Cross-Sudworth, F., A. Williams, and S. Herron-Marx, Maternity services in multicultural Britain: using Q methodology to explore the views of first- and second-generation women of Pakistani origin. *Midwifery*, 2011. 27(4): p. 458-468.
- [50] Chang, S.O., et al., Exploring ego-integrity in old adults: a Q-methodology study. *International Journal of Nursing Studies*, 2008. 45(2): p. 246-56.
- [51] Jedeloo, S., et al., Preferences for health care and self-management among Dutch adolescents with chronic conditions: a Q-methodological investigation. *Int J Nurs Stud*, 2010. 47(5): p. 593-603.
- [52] Yang, Y. and D. Montgomery, Gaps or bridges in multicultural teacher education: A Q study of attitudes toward student diversity. *Teaching and Teacher Education*, 2013. 30(0): p. 27-37.
- [53] Morecroft, C., J. Cantrill, and M.P. Tully, Individual patient's preferences for hypertension management: A Q-methodological approach. *Patient Education and Counseling*, 2006. 61(3): p. 354-362.
- [54] ten Klooster, P.M., M. Visser, and M.D.T. de Jong, Comparing two image research instruments: The Q-sort method versus the Likert attitude questionnaire. *Food Quality and Preference*, 2008. 19(5): p. 511-518.
- [55] Hunter, W.C., Rukai indigenous tourism: Representations, cultural identity and Q method. *Tourism Management*, 2011. 32(2): p. 335-348.
- [56] Hall, C., Identifying farmer attitudes towards genetically modified (GM) crops in Scotland: Are they pro- or anti-GM? *Geoforum*, 2008. 39(1): p. 204-212.
- [57] Clare, S., N. Krogman, and K.J. Caine, The "balance discourse": A case study of power and wetland management. *Geoforum*, 2013. 49(0): p. 40-49.
- [58] Boscolo, P. and L. Cisotto, Instructional strategies for teaching to write: a Q-sort analysis. *Learning and Instruction*, 1999. 9(2): p. 209-221.
- [59] Brodt, S., K. Klonsky, and L. Tourte, Farmer goals and management styles: Implications for advancing biologically based agriculture. *Agricultural Systems*, 2006. 89(1): p. 90-105.
- [60] Curry, R., J. Barry, and A. McClenaghan, Northern Visions? Applying Q methodology to understand stakeholder views on the environmental and resource dimensions of sustainability. *Journal of Environmental Planning and Management*, 2012: p. 1-26.
- [61] Cools, M., et al., Optimizing the implementation of policy measures through social acceptance segmentation. *Transport Policy*, 2012. 22(0): p. 80-87.
- [62] Cools, M., et al., Shifting towards environment-friendly modes: profiling travelers using Q-methodology. *Transportation*, 2009. 36(4): p. 437-453.
- [63] Srivastava, A. and S.B. Thomson, Framework analysis: a qualitative methodology for applied policy research. *JOAAG*, 2009. 4(2): p. 72-79.
- [64] Leech, N.L. and A.J. Onwuegbuzie, An array of qualitative data analysis tools: A call for data analysis triangulation. *School Psychology Quarterly*, 2007. 22(4): p. 557-584.
- [65] Horn, J., A rationale and test for the number of factors in factor analysis. *Psychometrika*, 1965. 30(2): p. 179-185.