

## *The Study on Cost Comparisons of Various Card Sorting Methods*

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### **Abstract**

Card sorting has always been recognized as the most economical and effective method used to elicit users' cognition. It has been applied as the most common method to design libraries websites information architectures based on user centered design concepts. According to Nielsen's 2004 study, the most appropriate number of participants is 15 people to conduct card sorting experiments. In 2008, Paul commented that card sorting method spends more cost at the participant number and analysis time. He suggested to applying the modified Delphi card sorting method to resolve the situation. In the modified Delphi card sorting method, there are 9 participants to involve experiments in a linear fashion. Beside the seed participant, the rest ones were asked to revise the result made by the preceding participant. The final obtained result is regarded as the one of all of participants. In 2010, Shieh and Wu put forward the refined modified Delphi card sorting method which is similar to the Delphi card sorting method, but with limited rounds to at most 3. By the same number of participants, Shieh and Wu illustrated that their refined card sorting method is superior to Paul's in findability tests. In this research, we will further explore whether the refined modified Delphi card sorting is also superior to the method proposed by Paul or the traditional card sorting method in time cost. This study will give a mathematical model to demonstrate the result of this issue.

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## **Introduction**

With the dramatically rapid development of websites, people frequently and conveniently acquire their needed information on the internet. Some websites provide logical information architectures to help users find what they required from the websites. Others that do not have proper structures are not only to frustrate users, but also risk the possibility of losing them completely (Morville & Rosenfeld, 2006). How to help users retrieve the needed information easily and efficiently on websites is something important for website designers should concern and pay much attention to. Hawley (2008) pointed out that when developing a website containing large and complex information, website designers and usability researchers often apply card sorting method to help with the design of its information architecture.

Comparing to the traditional card sorting method, Paul (2008) proposed the modified Delphi card sorting not only to lower the cost of time and human effort, but also to bring quality results. Even with such advantages, there are no sufficient case studies adapted to websites development. The researchers argued that the modified Delphi card sorting still needs further more improvement. In 2010, Shieh and Wu proposed the refined modified Delphi card sorting method, a novel variant card sorting method. They conducted findability tests to prove that their card sorting method is superior to Paul's with the same human efforts. However, something left not yet known is that which one spends least time. In this paper, we will further give a mathematical model to explore the result of this issue.

## **Preliminaries**

In this section, we will give a brief description of some topics involved in this research, including card sorting, modified Delphi card sorting and refined modified Delphi card sorting.

## **Card Sorting**

Card sorting is a user-centered design method to increase a system's findability. The process involves sorting a series of cards, each labeled with a piece of content or functionality of websites, into groups that make sense to users or participants (Spencer, 2004). Card sorting can help insight into users' mental models that are patterns in how users would expect to find content or functionality of websites. With complete and in-depth understanding users' mental model, we can increase findability that makes websites more easy and intuitive to use.

Upchurch, Rugg, & Kitchenham (2001) noted that card sorting method was originated from George Kelly's Personal Construct Theory, which proposed that, although people have different views for categorizing objects, we still share some commonalities in human nature and can understand each other's viewpoints. On the other hand, the differences of us show our uniqueness. Card sorting can be applied to help us organize different levels information of websites, build different category navigations, integrate the labels on the user center design, and verify individual thought of users (Boulton, 2007). The card sorting data can be further analyzed by the quantitative method, cluster analysis. Deaton (2002) suggested that cluster analysis is particularly suitable for card sorting method because the generated results can show

the correlation among different cards. Martin & Kidwell (2001) stated that cluster analysis can reveal participants' thoughts and ideas for the overall relevance of the cards being studied. Hinkle (2008) also pointed out that cluster analysis is the most often used method for card sorting.

Card sorting has always been recognized as the most economical and effective method used to elicit users' cognition. Therefore, it has been applied as the most common method to help design libraries website information architectures based on user centered concepts. However, according to Nielsen's 2004 study, to conduct card sorting experiments, the most appropriate number of participants is about 15 people. Paul commented this issue of the number of participants as a waste of too much cost.

### **Modified Delphi Card Sorting**

In order to reduce the cost of number of recruiting participants and the time for data analysis, in 2008 Paul proposed a new card sorting method named modified Delphi card sorting method which is derived from the Delphi method. The Delphi method carries out card sorting in multiple times until not any modifications from participants. It sometimes is rather time consuming. Therefore, Paul applied a linear model in his modified Delphi card sorting method, beside the seed participant (first participant); other participants are asked one by one, to provide feedbacks toward preceding one's result. The iteration goes on until the last participant complete his comment feedbacks. The final obtained result is regarded as the one of all of participants. Usually, there are about 8 to 10 experts as participants. Actually, 9 participants were involved in this linear model experiment. The Figure 1 illustrates the procedure:

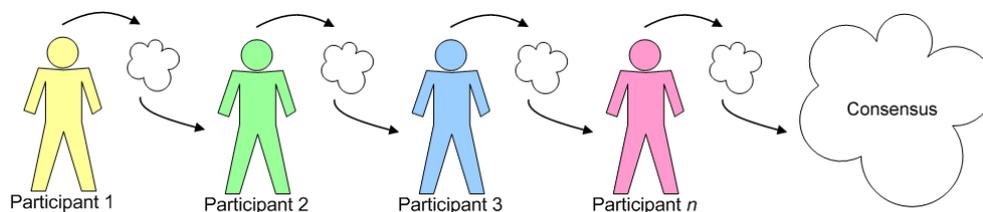


Figure 1. The procedure of modified Delphi card sorting (Paul, 2008)

### **Refined Modified Delphi Card Sorting**

For the purpose of effectiveness verification of Paul's proposal, Shieh and Wu (2010) put forwards a novel card sorting method named refined modified Delphi card sorting. The method is similar to the Delphi card sorting, but it limits rounds to at most 3 (Walker and Selfe, 1996). There are 9 website users participated in this experiment. In first round, participants propose his own card sorting structure, and then a new version structure is generated from all participants by an analysis tool such as EZCalc. Next, all participants are asked to comment the new version structure to produce another modified new structure again. This process continues in the same way to the third round to get the final structure. Figure 2 shows the procedure:

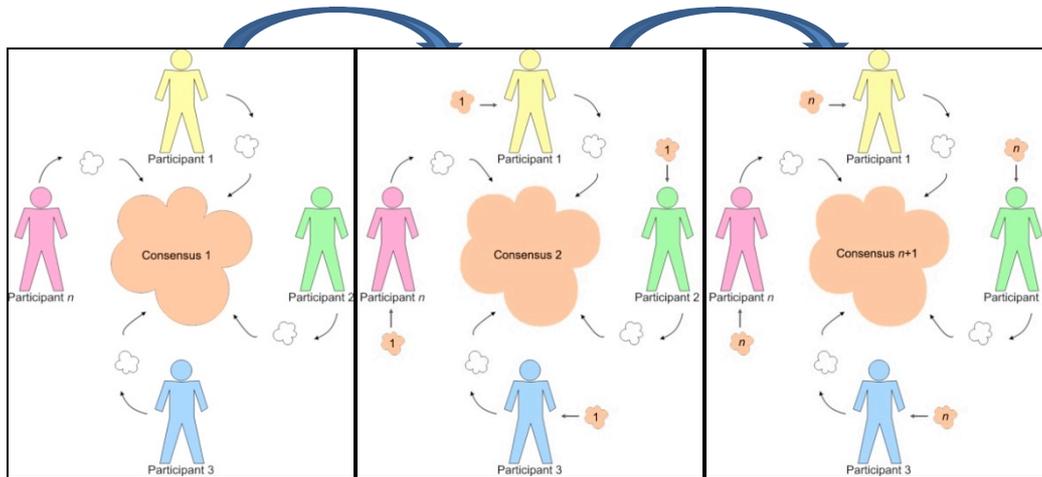


Figure 2. The procedure of refined modified Delphi card sorting (Shieh and Wu, 2010)

### Effectiveness Analysis

In order to further understand the advantages and disadvantages of different card sorting methods applied to construct website structures, it is necessary to carry out the effectiveness analysis. The effectiveness analysis of this study is based on the findability of websites those are constructed by various card sorting methods.

### Comparisons of Findability Measures

Shieh and Wu (2010) conduct findability tests for traditional card sorting method, modified Delphi card sorting method and refined modified Delphi card sorting method respectively. In their experiments, they applied 84 cards which were filtered from Library Website of National Taiwan Normal University according to the specific rules defined by Shieh a. For each findability test, there are 20 different participants involved. The comparisons of findability measures are depicted in Table 1 (Shieh and Wu, 2010), where structure A is generated from modified Delphi card sorting, structure B is constructed from traditional card sorting, structure C is produced from refined modified Delphi card sorting in first round, and structure D is generated from refined modified Delphi card sorting in second round. (There are no more changes in the third round of refined modified Delphi card sorting)

Table 1. The pairwise comparisons of findability measures on different structures

(I) Structure	(J) Structure	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
A	B	.387(*)	.125	.002	.140	.633
	C	-.092	.132	.486	-.355	.170
	D	-.328(*)	.117	.006	-.559	-.096
B	A	-.387(*)	.125	.002	-.633	-.140
	C	-.479(*)	.144	.001	-.763	-.195
	D	-.714(*)	.135	.000	-.982	-.447
C	A	.092	.132	.486	-.170	.355
	B	.479(*)	.144	.001	.195	.763
	D	-.235(*)	.095	.015	-.424	-.047
D	A	.328(*)	.117	.006	.096	.559
	B	.714(*)	.135	.000	.447	.982
	C	.235(*)	.095	.015	.047	.424

\* The significance level of Mean Difference is .05

From Table 1, it is obvious to see that the structure (structure D) generated from the second or third round of the refined modified Delphi card sorting method indeed contributes better performance in findability measure than traditional card sorting method and modified Delphi card sorting method.

### Time Cost Analysis

Time cost we discuss is defined as the time spent to complete card sorting tasks to construct its corresponding tree structure. In this section, we will first propose the mathematical model to verify the time costs of three different methods. Then, we will explore their time costs with more discussions based on our real case experiments.

### Mathematical model

Here we suppose that there are N participants. Each takes  $ct_i$  time to complete individual card sorting. The total time of each different method to accomplish the card sorting to construct its corresponding tree structure is:

- (1) Traditional method (N=15):  $\max_{1 \leq i \leq 15} (ct_i)$  + the time of tree structure construction from 15 participants;
- (2) Modified Delphi card sorting (N=9):  $\sum_{i=1}^9 ct_i$ ;
- (3) Refined modified Delphi card sorting (there are 9 participants, they take 3 rounds):  $(\max_{\text{round}1, 1 \leq i \leq m1} (ct_i) + \text{the time of tree structure construction from 9 participants}) + (\max_{\text{round}2, 1 \leq j \leq m2} (ct_j) + \text{the time of tree structure construction from 9 participants}) + (\max_{\text{round}3, 1 \leq k \leq m3} (ct_k) + \text{the time of tree structure construction from 9 participants})$ , where  $m1$ ,  $m2$  and  $m3$  are the numbers of participants who made feedbacks in each round;

In the above, the time of tree construction is about the time of applying computer tool such as EZCalc, or Optimal Sort to construct a corresponding tree structure of a pile of card sorting results generated by different participants. Nowadays, the tree structure construction time is much less than the time a participant takes to complete his card sorting task. With today computing power, here we may assume that the time of tree structure construction is less than the minimum time of participants takes to complete their card sorting tasks; even we can ignore it as comparing to manual card sorting time.

### Comparisons of time cost

In these three different methods, it is obvious that the modified Delphi card sorting takes the most time. Especially, the result made by the seed participant will have much impact on the following ones (Shieh and Chiou, 2013).

Table 2 shows the time spent by and whether feedback or not (FB or not) status of participants in different card sorting methods experiments. On the surface, the refined modified Delphi card sorting spends a lot of time. However, in our experiment tests, there are no more changes in the third round, that is  $\max_{\text{round}3, 1 \leq i \leq m3} (ct_i) = 0$ . As for the second round, few participants may make minor modifications, so  $\max_{\text{round}2, 1 \leq i \leq m2} (ct_i) = 27$ . Thus the refined modified Delphi card sorting will take about  $\max_{\text{round}1, 1 \leq i \leq 9} (ct_i) = 60 + 27 = 87$  minutes to complete card sorting task. Its time cost is much less than modified Delphi card sorting (420 minutes). The refined modified Delphi card sorting method takes more time than traditional method that takes about  $\max_{1 \leq i \leq 9} (ct_i) = 63$  minutes, but is involved with fewer (9 versus 15) participants.

Table 2. The time spent by participants in different card sorting experiment

No.	Traditiona l	Modified Delphi	Refined Modified Delphi					
			Round 1	FB or not	Round 2	FB or not	Round 3	FB or not
1	35	98	23	Y	27	Y	8	N
2	59	32	31	Y	17	Y	13	N
3	33	35	60	Y	43	N	10	N
4	32	54	44	Y	38	N	30	N
5	25	42	22	Y	30	N	10	N
6	31	39	30	Y	25	N	15	N
7	35	41	16	Y	23	Y	4	N
8	32	36	48	Y	32	N	11	N
9	63	43	21	Y	38	N	8	N

(in minute)

## **Conclusions**

Card sorting has been recognized as the most economical and effective method used to elicit users' cognition. It is often applied as the most common method to help design website information architectures. Some variant improved card sorting methods have been suggested in recent years. In this research, we propose mathematical models to explore the time cost for various card sorting methods.

Modified Delphi card sorting proposed by Paul is expect to reduce the cost of traditional card sorting method in the number of participants and time spent to complete the task. In this research we verify that the modified Delphi card sorting method takes the most time to carry out the card sorting tasks, even it had involved fewer participants. Traditional card sorting is still the time less method. However, it is obvious that what to be criticized is it recruits more participants (at least 15 persons).

From both effectiveness and time cost analysis, refined modified Delphi card sorting, proposed by Shieh and Wu, is another good choice to information architecture applications: It not only takes time much less than modified Delphi card sorting and is involved fewer participants than the traditional method, but also has better findability effectiveness over other two methods.

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