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Executive Summary
Meetings are one of the major activities in offices. How to improve meeting productivity is also a main concern to both researchers and managers. Since 1980s, the widespread of personal computers and communication networks has enabled a new technology called *electronic meeting*. An *electronic meeting system* (EMS) is a computer-based software that allows people in different places to discuss and make decisions on connected computers.

The use of EMS is said to be able to overcome a few major drawbacks of the traditional face-to-face meeting, such as groupthink and blocking effects. The system allows participant to discuss anonymously. This increases the participants' willingness to create more ideas or more creative ideas. The computer network also allows more people to present their ideas simultaneously. Given these potential benefits, several teams have conducted a number of research to investigate whether using EMS increases meeting productivity or participants' satisfaction. Unfortunately, the results, as shown in the many published articles, have been inconclusive in many aspects.

The objective of this paper is to conduct a meta-analysis to synthesize the possibly conflicting observations in existing literature of EMS laboratory experiments. In this research, thirty-five papers published in academic journals were collected and analyzed using both qualitative and quantitative analysis techniques to examine how contextual variables (anonymity, EMS use, facilitator, group size, leadership, and proximity) influence meeting process and outcome. The results show that:

(1) EMS enable larger groups have higher productivity and decision quality;
(2) Anonymity enhances meeting productivity, but decreases member satisfaction;
(3) EMS equalizes member participation, increases both productivity and decision quality, but requires longer discussing time;
(4) Facilitated groups are harder to reach consensus than unfacilitated groups;
(5) Small groups are more satisfied than large groups;
(6) Face-to-face meetings have higher member satisfaction than dispersed groups.

The paper also indicates new areas and guidelines for further research.

Keywords: Electronic Meeting Systems, Group Decision Support Systems, Meta-Analysis, Information Systems Evaluation.

1. Introduction

Meetings are a major activity in most offices. Many survey results have shown that managers and professionals spend a considerable amount of time in ineffective meetings, which often consume 60% to 70% working hours for information systems managers and 30% to 80% for general managers (Dennis et al., 1988). Therefore, improving meeting productivity has been a major concern to both researchers and professionals. Since 1980's, the advances in computers and communication networks have enabled a new technology called *electronic meeting systems* (EMS) or *group decision support systems* (GDSS).

An EMS is a computer-based information system designed to facilitate meeting processes for higher productivity. A typical EMS allows users to present their ideas and comments simultaneously and anonymously, organize their ideas, and sometimes make decisions using voting or other group tools. Nunamaker et al. (1991) argues that using EMS has seven advantages: (1) it enables all participants to work simultaneously, (2) it provides an equal opportunity for participation, (3) it discourages behavior that can negatively impact meeting productivity, (4) it enables larger group meetings which

can effectively bring more information, knowledge, and skills to bear on the task, (5) it permits the group to choose from a spectrum of structured or unstructured techniques and methods to perform the task; (6) it offers access to external information; (7) it supports the development of an organizational memory from meeting to meeting. These advantages provide opportunities for increasing process gains and decreasing process losses.

Although the above benefits seem intuitively true, empirical findings have been conflicting in many cases. For instance, George et al. (1990) found EMS-supported groups were not different from non-EMS group in many observations. However, Easton et al. (1992) found that EMS-supported groups generated more ideas, participated more equally, felt more satisfied, and had better decision quality in their experiments. In order to consolidate these conflicting finding, a few meta-research have been performed. More recent ones are McLeod (1992) and Benbasat and Lim (1993). McLeod (1992) focuses on the impact of EMS use, whereas Benbasat and Lim (1993) focuses on the effect of EMS use. Although these papers have successfully consolidated some findings, many new experiments published after 1992 have not been examined to see whether their conclusions are still true. Given the new evidence, it seems to be necessary to perform a research to examine whether the previous findings are still valid, what findings are true (or are not true) and why they are or are not true.

The purpose of this research is to further investigate the experimental findings using the meta-analytic method. Thirty-five published experimental research between 1980 and 1995 were analyzed. The results show that (1) EMS enable larger groups to have higher productivity and decision quality, (2) anonymity enhances meeting productivity, but decreases member satisfaction; (3) EMS equalizes member participation and increases both productivity and decision quality, but requires longer discussing time; (4) facilitated groups are harder to reach consensus than unfacilitated groups; (5) small groups are more satisfied than large groups; (6) face-to-face meetings have higher member satisfaction than dispersed groups.

The remainder of the article is organized as follows. EMS research literature, including conflicting findings and a few works intended to resolve the conflicts, is briefly reviewed in Section 2. The research framework and procedures for the meta-analytic method are presented in Section 3. Research findings are discussed in Sections 4 and 5. Conclusions are in Section 6.

2. Literature Review

Research in EMS falls into three general categories. One is to develop concepts for application and frameworks for research (e.g., Dennis et al., 1988; DeSanctis and Gallupe, 1985; DeSanctis and Gallupe, 1986; Nunamaker et al., 1991). Their major focus is to identify the scope and value of EMS. Another direction is to construct EMS systems. Related issues include the analysis, design and implementation of EMS in organizations. Several systems have been developed successfully, such as the GroupSystems of the University of Arizona and SAMM of the University of Minnesota. The third is to evaluate whether EMS improve meeting productivity empirically in laboratories or in the field.

In order for EMS to be useful in the real world, showing consistent performance is necessary. Unfortunately, this is often not the case empirically. For example, Gallupe and DeSanctis (1988) applied repeat measure techniques to evaluate the extent to which the EMS use and task difficulty might influence meeting performance. They found that the EMS-supported group outperformed non-EMS groups in decision quality, number of alternatives raised, meeting consensus, and overall satisfaction. The degree of conflict during the meeting was also higher for the EMS-supported group.

George et al. (1990) investigated the effects of selected contextual variables (EMS use, leadership, and anonymity) on group meetings. In their findings, the performance of the EMS-supported group was not different from that of the non-EMS group in many aspects, such as decision quality, number of alternatives raised, overall satisfaction, participation equality, and uninhibited behavior, which virtually reversed the observations in Gallupe and DeSanctis (1988).

In a later work, Easton et al. (1992) observed six EMS-supported and six non-EMS meetings to found that the EMS-supported group generated more ideas, participated more equally, felt more satisfied, and had a better decision quality. However, the EMS-supported group took longer time to finish meetings.

The inconsistent findings often confuse potential EMS users in what gains or losses they can expect from using the system. Fortunately, the large amount of empirical research allows us to consolidate findings from individual work. Since 1990, five meta-research on EMS have been published. Three of them use qualitative comparisons and two adopt quantitative analysis.

Pinsonneault and Kraemer (1990) was the first attempt to compare findings from individual empirical work. They divided EMS into two categories: Group Decision Support Systems (GDSS) and Group Communication Support Systems (GCSS). They compared the impact of these systems on group performance and found (1) both GDSS and GCSS increased the depth of analysis, member participation, decision quality, but decreased certain member's domination in the process; (2) GDSS increased group consensus, confidence, and member satisfaction, but lengthened the decision time; (3) GCSS increased the time to reach a decision, but reduced confidence in decisions and member cooperation.

Benbasat and Nault (1990) summarizes empirical studies of decision support systems (DSS), GDSS, and expert systems (ES). In GDSS, they found that: (1) using GDSS enhanced decision quality, especially when the task complexity was high; (2) applying GDSS encouraged participants to consider much more alternatives; (3) the mutual influence of meeting members was indifferent between GDSS meetings and traditional meetings; (4) the degree of consensus change in GDSS groups was inconclusive since the results of independent experiments were not in accordance.

Dennis et al. (1991) compared EMS laboratory and field research published before 1990 and found that EMS laboratory experiments had often drawn very different conclusions from those of EMS field studies. The results from laboratory experiments were inconclusive, but the results from EMS field studies were firmly consistent. That is, EMS can raise working efficiency, effectiveness and satisfaction.

The first research using quantitative analysis to synthesize EMS experimental research was McLeod (1992). In the research, McLeod examined the experimental studies published between 1980 and 1990 to study the relationship between EMS use and group process/outcome variables, such as task focus, participation, time to decision, decision quality, consensus and satisfaction. The results showed that EMS increased decision quality, decision time, equality of participation, degree of task focus, but decreased consensus and satisfaction.

Benbasat and Lim (1993) was another work that applied meta-analytic procedures to integrate the experimental results with respect to the effects of EMS use. Their findings showed that the use of EMS had positive effects on decision quality, number of alternatives generated, and equality of participation, but had negative effects on the time to reach a decision, consensus, and satisfaction. They also used linear regression techniques to study the effect of moderated variables on outcome variables. The results showed that: (1) when using EMS, larger groups achieved better performance and higher satisfaction than those of smaller groups; (2) when using EMS, groups with a formal hierarchy performed worse in both performance and satisfaction compared to groups without a formal hierarchy; (3) the level of EMS support was influential in almost all dependent variables.

Table 1 summarizes the existing comparative research related to EMS use. Although they have provided insights into certain issues, there are some important issues that have not been examined. For example, the effects of anonymity, group size, or proximity on productivity have not been studied. Furthermore, their analyses were based on research published before 1992. Since then, a number of new results have been reported. It is, therefore, important to take into account the new evidences and new issues to see whether the previous conclusions will be confirmed or denied.

Authors	Sampling Period	Research Strategy	System Type	Summary
Pinsonneault & Kraemer (1990)	1981-1988	qualitative	GCSS & GDSS	Applying an analysis framework (include contextual variables, group process variables and outcome variables) to compare the relationship between EMS support level (GCSS vs. GDSS) and group outcomes.
Benbasat & Nault (1990)	1981-1988	qualitative	ES, DSS & GDSS	Using a classification table (include research purpose, research strategy, focus of research, decision aid technique and results) to organize related researches and discuss the relationship between MSS design and performance.
Dennis, Nunamaker, & Vogel (1991)	1981-1990	qualitative	EMS	Comparing laboratory experiments by four groups of variables (organizational contexts, group characteristics, tasks, and EMS technology) and discussing how these variables influence group performance.
McLeod (1992)	1980-1990	quantitative	GSS to support meetings	Exploring the influence of EMS use on task focus, participation, time to decision, decision quality, consensus, and satisfaction.
Besbasat & Lim (1993)	1970-1992	quantitative	GSS to support meetings	Exploring the influence of EMS use (main effect) and moderating variables on performance, satisfaction, and structural products. It also included many detailed variables.

Table 1. Previous EMS Meta-Research

3. Research Methodology

This research includes four major steps: (1) framework construction, (2) literature survey, (3) data coding, (4) qualitative and quantitative analyses. We shall describe them sequentially.

3.1 Research Framework

EMS related factors are generally divided into three categories: contextual variables, group process variables, and outcome variables (Dennis and Gallupe, 1993; Dennis et al., 1988; Gopal et al., 1993; Gray, 1987; Pinsonneault and Kraemer, 1989 and 1990). Contextual variables refer to the experimental settings of research hypotheses that directly imposed on groups. Among EMS laboratory experiments, six contextual variables are often studied. They are (1) anonymity (the degree to which the origin of an opinion or action can be identified); (2) EMS use (the absence or presence of functional supports from EMS); (3) facilitator (the absence or presence of a technical or procedural assistant); (4) group size (depending on the number of people in a group, typically divided into large and small groups); (5) leadership (the absence or presence of a group leader); (6) proximity (the degree to which participants can direct contact each other).

Group process variables refer to factors that influence group interaction. Three group process variables are included in our research model: (1) equality (the degree to which each participant has equal chance to speak); (2) decision time (time spend in a group meeting); (3) consensus (the feeling of agreement during and after a meeting).

Outcome variables refer to subjective and objective measures that reflect the outcome of group meetings. Three outcome variables are included in our research model: (1) productivity (the quantity of meeting outputs, includes alternatives and comments generated); (2) decision quality (the quality of group works, typical indicators are quality of ideas, quality of meetings, and deviation from the correct answer); (3) satisfaction (a measure of subjective feelings that evaluates the degree of overall comfort of meeting participants).

The relations among contextual variables, group process variables and outcome variables are shown in Figure 1. Three types of relationship are indicated in the Figure: (1) the relationship between contextual variables and group process variables, (2) the relationship between contextual variables and outcome variables, and (3) the relationship between group process variables and outcome variables. Since most EMS laboratory experiments focus on the first two relationships, we chose not to include the third one (the broken line in Figure 1) in our research framework, due to lack of primary work.

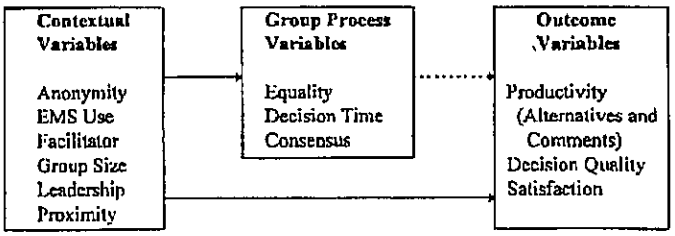

Figure 1. Research Framework

3.2 Sample

The research sample was defined as experimental work published in major academic journals. We decided to exclude unpublished work because we believed that papers undergone the journal review process were more likely to have a higher validity. Based on this guideline, we surveyed major IS journals such as MIS Quarterly, Communications of the ACM, Journal of Management Information Systems, Information Systems Research, Decision Support Systems, Management Science, Decision Sciences, and Information & Management and related journals such as Computer Supported Cooperative Work and Group Decision and Negotiation. A total of 35 articles published between 1981 and 1995 were identified (they are listed in Appendix 1). Their distribution is shown in Table 2. We can see in the table that *EMS use* has been the most popular factor under study, followed by proximity and Anonymity. Most articles were published after 1990.

Source		Time		Variables	
Journal Name	No.	Year	No.	Var. Name	No.
MIS Quarterly	7	Before 1987	2	Anonymity	7
Information & Management	5	1988	4	EMS Use	21
Journal of MIS	4	1989	1	Facilitator	3
Management Science	3	1990	7	Group Size	4
Decision Support Systems	3	1991	5	Leadership	4
Group Decision & Negotitation	3	1992	6	Proximity	8
IEEE T. on Sys., Man, and Cybernetics	2	1993	2		
Journal of Applied Psychology	2	1994	5		
Others	6	1995	3		
Total	35	Total	35	Total	35

Table 2. Sample Distribution

3.3 Data Coding

Data encoding included two steps. First, the authors discussed to decide the coding method. During this stage, definition of each research variable was reviewed and agreed. For qualitative analysis, we adopted the significant level at a=0.05. That is to say, only the difference between experimental groups and control groups exceeded the 5 percent level was considered significant.

Then, the 35 articles were read and coded independently by at least two authors. When inconsistency was found, the rest author would review the paper and discussed to resolve it.

3.4 Data Analysis

The coded data were first analyzed qualitatively. Briefly speaking, all relations examined in the sample were classified based on their independent variable, dependent variable, and degree of significance. If findings concerning a relation from different research in the sample were consistent, then the relation was considered conclusive. Otherwise, it was forwarded for quantitative meta-analysis.

Meta-analysis offers a chance to objectively accumulate statistical results across studies without requiring access to original data. The basic concepts and techniques of meta-analysis can be found in Hedges and Olkin (1985), Wolf (1986), Hunter and Schmidt (1990), Johnson et al. (1995), and so on. As stated in Wolf (1986), applying meta-analysis can avoid potential problems with traditional literature reviews such as (1) selective inclusion of studies; (2) differential subjective weighting of studies in the interpretation of findings; (3) misleading interpretations of study findings; (4) failure to examine potential explanations for disparate or consistent results across studies; (5) failure to examine moderating variables in the relationship under examination.

In order to combine the findings of studies that are based on different statistical tests, meta-analysis procedures convert these tests to a common effect size, which represents the effect of an independent variable on the dependent variable. The effect size *d* of a given hypothesis in a study is calculated as:

$$d = \frac{\overline{X_1} - \overline{X_2}}{SD}$$

In this formula, $\overline{X_1}$ and $\overline{X_2}$ represent the means of experimental groups and control groups respectively, while SD is the average standard deviation of the two groups. For each research hypothesis, after calculating all *d* values from related studies, we further computed several indices, including an overall effect size (d_u), a summary index of the statistical significance (Z_c), a homogeneity test (χ^2), and an index of the strength of the hypothesis ($N_{fs.1}$). All of these indices show the overall significance and robustness of the resulting conclusion.

4. Results

4.1 Qualitative Observations

A total of 38 hypotheses were examined in the qualitative analysis. Here each hypothesis is a mapping between an independent variable and a dependent variable, as shown in Table 3. Since most research uses two productivity measures(the number of alternatives generated and the number of comments provided) when they study anonymity and proximity, we also separate them in this research. A hundred and twenty-six observations were collected from the sample. Some show significantly increasing or decreasing relationships, while others are insignificant. Table 3 summarizes the result. The shaded areas in Table 3 (19 of the 38 hypotheses) indicate consistent results. Among the consistent hypotheses, only three related to group size and one related to proximity are significant. If we discount the reliability of the two hypotheses (group size and proximity on decision time) having only one observation as areas that need more research, then only two significant hypotheses are valid. That is, *larger groups tend to have higher productivity and decision quality.* The cohesive, inconsistent, and underexplored hypotheses are listed in Table 4.

Independent Variable	Dependent Variable	Increase Significantly	Not Significant	Decrease Significantly
Anonymity (anonymous)	Equality		18, 19, 33	
	Decision Time		18	
	Consensus		18, 19	
	Productivity(Alt.)		7, 18, 24, 25, 33	
	Productivity(Com.)	7, 24, 33	19, 25, 35	
	Decision Quality		7, 18, 33	
	Satisfaction	33	7, 18, 25	
EMS Use (with EMS)	Equality	1, 11, 18, 26, 32	14, 21, 23, 27, 34	
	Decision Time	13, 18	11, 22	
	Consensus	5	2, 34	12, 18, 21
	Productivity	11, 12, 14, 15, 16, 27	18, 22	
	Decision Quality	12, 15, 22, 23	10, 11, 13, 18, 30	4
	Satisfaction	1, 15	2, 13, 14, 16, 22, 23	4, 11, 12, 18
Facilitator (with facilitator)	Equality			
	Decision Time			
	Consensus		2	9, 17
	Productivity		17	
	Decision Quality		17	
	Satisfaction		17	
Group Size (large groups)	Equality		8, 33	
	Decision Time	22		
	Consensus			
	Productivity	8, 22, 33		
	Decision Quality	8, 22, 33		
	Satisfaction	8	22, 33	1
Leadership (with leader)	Equality	26	18, 21	
	Decision Time		18	
	Consensus		18, 20, 21	
	Productivity		18	
	Decision Quality		18, 20	
	Satisfaction		18, 20	
Proximity (face-to-face)	Equality	28	3, 29	
	Decision Time			13
	Consensus	31	3	
	Productivity(Alt.)		6, 25, 31	
	Productivity(Com.)	28, 29		25, 31
	Decision Quality	28	3, 6, 13, 29	
	Satisfaction	13, 25	4	

Note: The numbers in the table refer to the literature listed in Appendix 1

Table 3. Data Distribution in Qualitative Analysis.

	Contextual Variable	Effects on Process or Outcomes
Cohesive Conclusion	Anonymity	1. Equality (Anonymous Groups = Identified Groups) 2. Decision Time (Anonymous Groups = Identified Groups) 3. Consensus (Anonymous Groups = Identified Groups) 4. Productivity - Alt. (Anonymous Groups = Identified Groups) 5. Decision Quality (Anonymous Groups = Identified Groups)
	Facilitator	1. Productivity - Alt. (Facilitated = Non Facilitated) 2. Decision Quality (Facilitated = Non Facilitated) 3. Satisfaction (Facilitated = Non Facilitated)
	Group Size	1. Equality (Large Groups = Small Groups) 2. Decison Time (Large Groups > Small Groups) 3. Productivity - Alt. (Large Groups > Small Groups) 4. Decision Quality (Large Groups > Small Groups)
	Leadership	1. Decision Time (Leaded Groups = Unleaded Groups) 2. Consensus (Leaded Groups = Unleaded Groups) 3. Productivity - Alt. (Leaded Groups = Unleaded Groups) 4. Decision Quality (Leaded Groups = Unleaded Groups) 5. Satisfaction (Leaded Groups = Unleaded Groups)
	Proximity	1. Decision Time (Face-to-Face Groups < Dispersed Groups) 2. Productivity - Alt. (Face-to-face Groups = Dispersed Groups)
Inconsistent Findings	Anonymity	1. Number of Comments 2. Satisfaction
	EMS Use	1. Equality 4. Number of Alternatives 2. Decision Time 5. Decision Quality 3. Consensus 6. Satisfaction
	Facilitator	1. Consensus
	Group Size	1. Satisfaction
	Leadership	1. Equality
	Proximity	1. Equality 4. Decision Quality 2. Consensus 5. Satisfaction 3. Number of Comments
Future Research Areas (discussed less than twice)	Anonymity	1. Decision Time
	Facilitator	1. Equality 3. Productivity 5. Satisfaction 2. Decision Time 4. Decision Quality
	Group Size	1. Decision Time 2. Consensus
	Leadership	1. Decision Time 2. Productivity
	Proximity	1. Decision Time

Table 4. Results from the Qualitative Analysis

4.2 Quantitative Analysis

To consolidate the inconsistent hypotheses in Table 4, quantitative analysis was performed. Among the 35 papers in the sample, eight of them (marked with * in Appendix 1) do not provide sufficient statistic data for quantitative analysis. Therefore, only 27 articles retained at this stage. The results from quantitative analysis are illustrated in Table 5 and summarized below.

Independent Variables	Dependent Variables	χ^2 (1)	Z_c (2)	d_u (3)	$N_{fs.1}$ (4)	Results
Anonymity	Equality	0.58	0.31	0.11	0.20*	n.s.
	Productivity (Alt.)	3.66	1.01	0.20	5.00	n.s.
	Productivity (Com.)	3.03	6.38*	1.32	48.80	Anonymous groups make more comments.
	Decision Quality	3.28	-0.24	0.05	-	n.s.
	Satisfaction	3.85	-1.93*	0.43	13.20	Anonymous groups are less satisfied.
EMS Use	Equality	12.27*	5.25*	0.69	35.40	EMS groups participate more equally.
	Decision Time	9.40*	2.96*	0.79	21.00	EMS groups take more time to decision.
	Consensus	31.20*	0.43	0.02	-	n.s.
	Productivity (Alt.)	14.22*	6.72*	1.21	66.30	EMS groups have higher productivity.
	Decision Quality	12.44*	5.58*	0.84	51.80	EMS groups have better decision quality.
	Satisfaction	80.00*	1.23	0.08	-	n.s.
Facilitator	Consensus	3.74	-2.12*	0.50	12.00	No facilitator is easier to reach a consensus.
Group Size	Equality	0.18	0.77	0.27	3.40	n.s.
	Productivity (Alt.)	27.43*	12.94*	1.98	56.40	Large groups generate more alternatives.
	Decision Quality	32.01*	12.36*	1.72	48.60	Large groups have better decision quality.
	Satisfaction	4.64	-0.74	0.42	12.80	n.s.
Leadership	Equality	8.23*	1.06	0.18	2.40	n.s.
	Consensus	4.42	0.70	0.09	-	n.s.
	Decision Quality	0.09	0.58	0.15	1.00	n.s.
	Satisfaction	0.15	0.37	0.05	-	n.s.
Proximity	Productivity (Alt.)	0.02	-0.72	0.23	2.60	n.s.
	Productivity (Com.)	17.93*	-0.62	0.15	1.00	n.s.
	Decision Quality	2.38	0.85	0.21	3.30	n.s.
	Satisfaction	1.64	-2.84*	0.46	10.80	Face-to-face groups are more satisfied.

Note: 1. χ^2 is the value of heterogeneity index; Z_c is the result from the combine test; d_u shows the effect size, and $N_{fs.1}$ shows the fail-safe N value.

2. "*" stands for significance at $p < 0.05$

Table 5. Results of the Quantitative Analysis

Anonymity

Two hypotheses are significant. (1) Anonymous groups generate more comments than the identified groups (Z_C=6.38, p<0.0001). The finding has a large effect size (d_U=1.32) and great stability ($N_{fS.1}$=48.8). (2) Anonymous groups are less satisfied than the identified groups (Z_C=-1.93, p<0.05). The finding has a medium effect size (d_U=0.43) and moderate stability ($N_{fS.1}$=13.2).

EMS use
Four hypotheses are significant. (1) EMS-supported groups participate more equally than non-EMS groups (Z_C=5.25, p<0.0001). The finding has a medium effect size (d_U=0.69) and great stability ($N_{fs.1}$=35.4). (2) EMS-supported groups spend more time to reach a decision than non-EMS groups (Z_C=2.96, p<0.01). The finding has a large effect size (d_U=0.79) and great stability ($N_{fs.1}$=21.0). (3) EMS-supported groups generate more alternatives than non-EMS groups (Z_C=6.72, p<0.0001). The finding has a large effect size (d_U=1.21) and great stability ($N_{fs.1}$=66.3). (4) EMS-supported groups have better decision quality than non-EMS groups (Z_C=5.58, p<0.0001). The finding has a large effect size (d_U=0.84) and great stability ($N_{fs.1}$=51.8). The high heterogeneity indices (χ^2) show that, among independent research, the measurement of the same dependent variable may be quite different. The results should be read cautiously.

Facilitator
One significant hypothesis related to the use of facilitators is found. That is, groups without a facilitator are easier to reach a consensus (Z_C=-2.12, p<0.05). The finding has a medium effect size (d_U=0.50) and moderate stability ($N_{fs.1}$=12.0). Other process and outcome variables can not be analyzed due to the scarcity of available statistic data.

Group Size
Two hypotheses are significant. (1) Large groups generate more alternatives than small groups (Z_C=12.94, p<0.0001). The finding has a large effect size (d_U=1.98) and great stability ($N_{fs.1}$=56.4). However, the heterogeneity value is relatively high (c^2=27.43, p<0.001), which indicates the measurement of alternatives may be quite different in different studies. (2) Large groups have better decision quality (Z_C=12.36, p<0.0001). The finding has a large effect size (d_U=1.72) and great stability ($N_{fs.1}$=48.6). The heterogeneity value is also a little high (c^2=32.01, p<0.001). We did not have adequate data to analyze decision time and consensus.

Leadership
None of the hypotheses is significant. It indicates that the existence of leadership has no effect on the decision process, nor the outcome in group decision. We did not have adequate data to analyze decision time and productivity.

Proximity
One significant hypothesis is found. That is, face-to-face groups are more satisfied than dispersed groups (Z_C=-2.84, p<0.01). The finding has a medium effect size (d_U=0.46) and moderate stability ($N_{fs.1}$=10.8). We did not have adequate data to analyze equality, decision time and consensus.

Table 6 compares the results of qualitative and quantitative analyses. The quantitative analysis was able to resolve most inconsistent findings in qualitative analysis except for proximity to equality and proximity to consensus, which need more experimental data.

Hypotheses	Qualitative Results	Quantitative Results
Anonymity→Equality	n.s.	n.s.
Decision Time	n.s.	n.a.
Consensus	n.s.	n.a.
Productivity (Alt.)	n.s.	n.s.
Productivity (Com.)	**inconsistent**	**Anonymous > Identified**
Decision Quality	n.s.	n.s.
Satisfaction	**inconsistent**	**Identified > Anonymous**
EMS Use → Equality	**inconsistent**	**Use > Not use**
Decision Time	**inconsistent**	**Use > Not use**
Consensus	**inconsistent**	**n.s.**
Productivity (Alt.)	**inconsistent**	**Use > Not use**
Decision Quality	**inconsistent**	**Use > Not use**
Satisfaction	**inconsistent**	**n.s.**
Facilitator → Consensus	**inconsistent**	**No facilitator > Facilitator**
Group Size→Equality	n.s.	n.s.
Decision Time	Large > Small	n.a.
Productivity	Large > Small	Large > Small
Decision Quality	Large > Small	Large > Small
Satisfaction	**inconsistent**	**n.s.**
Leadership→ Equality	**inconsistent**	**n.s.**
Decision Time	n.s.	n.a.
Consensus	n.s.	n.s.
Productivity	n.s.	n.a.
Decision Quality	n.s.	n.s.
Satisfaction	n.s.	n.s.
Proximity → Equality	**inconsistent**	**n.a.**
Decision Time	Face-to-Face < Dispersed	n.a.
Consensus	**inconsistent**	**n.a.**
Productivity (Alt.)	n.s.	n.s.
Productivity (Com.)	**inconsistent**	**n.s.**
Decision Quality	**inconsistent**	**n.s.**
Satisfaction	**inconsistent**	**Face-to-Face > Dispersed**

Note: n.s. = not significant; n.a. = not available.

Table 6. Comparisons of the Results of Qualitative and Quantitative Analysis

5. Discussion

The above results have reached some solid conclusions with respect to the effect of EMS. An interesting issue would be how the results compare to prior meta-research such as McLeod (1992) and Benbasat and Lim (1993). Table 7 summarizes the major findings in three different research.

		This Study	McLeod	Benbasat and Lim
Anonymity	Equality	n.s.	n.a	n.a
	Productivity (Alt.)	n.s.	n.a	n.a
	Productivity (Com.)	Anonym. > Identi.	n.a	n.a
	Decision Quality	n.s.	n.a	n.a
	Satisfaction	Anonym. > Identi.	n.a	n.a
EMS Use	Equality	Use > Not use	Use > Not use	Use > Not use
	Decision Time	Use > Not use	Use > Not use	Use > Not use
	Consensus	n.s.	Not use > Use	Not use > Use
	Productivity (Alt.)	Use > Not use	n.a.	Use > Not use
	Decision Quality	Use > Not use	Use > Not Use	Use > Not use
	Satisfaction	n.s.	Not use > Use	Process: n.s. Outcome: Not use > Use Confidence: n.s.
Facilitator	Consensus	No facilit. > Facilit.	n.a	n.s.
Group Size	Equality	n.s.	n.a	n.s.
	Productivity (Alt.)	Large > Small	n.a	n.s.
	Decision Quality	Large > Small	n.a	Large > Small
	Satisfaction	n.s.	n.a	Process: Large > Small
Leadership	Equality	n.s.	n.a	n.a.
	Consensus	n.s.	n.a	n.a.
	Decision Quality	n.s.	n.a	n.a.
	Satisfaction	n.s.	n.a	n.a.
Proximity	Productivity (Alt.)	n.s.	n.a	n.a.
	Productivity (Com.)	n.s.	n.a	n.a.
	Decision Quality	n.s.	n.a	n.a.
	Satisfaction	Face-to-Face > Disp.	n.a	Face-to-Face > Disp.

Note: 1.n.s. = not significant; n.a. = not available.

2. The shaded area indicates inconsistency between this research and the other two.

Table 7. Comparison Of Research Findings

Although the majority of the hypotheses are consistent among the three works, we find two new and five controversial conclusions. Neither McLeod (1992) nor Benbasat and Lim (1993) examined the effect of anonymity. This research concludes that anonymity can increase the number of comments (but not alternatives) made in the process but participants are less satisfied (probably due to the increased amount of comments).

Inconsistent findings among them include the effect of EMS use on consensus and satisfaction, the effect of facilitators, and the effect of group size on productivity and satisfaction.

Effect of EMS Use
The effect of EMS on consensus was significant in both McLeod (1992) and Benbasat and Lim (1993), but insignificant in this study. An examination of the papers related to the issue (Table 3) shows that it was due to the inconclusive result reported in paper #2 in the sample. A further examination of Table 5 shows that the heterogeneity associated with this hypothesis is very high. Therefore, we can reasonably believe that the conclusion in McLeod (1992) and Benbasat and Lim (1993) is brittle.

The effect of EMS on satisfaction was found significant in McLeod (1992) and partially significant in Benbasat and Lim (1993), but insignificant in this study. This inconsistency was also due to new evidences provided in papers #1,2,16,and 22 in our sample. Again, the heterogeneity associated with this hypothesis (in Table 5) is very high.

Effect of Facilitators
The effect of facilitators on consensus was reported insignificant in Benbasat and Lim (1993) but found significant in our research. This is also due to new evidence in paper #9 and 17 in the sample, which found significant negative effect. Considering the data in Table 5, our conclusion is moderately stable.

Effect of Group Size
The effect of group size was found to have no significant effect on productivity in Benbasat and Lim (1993), but have significant effect in this study -- large groups generate more alternatives. This is due to new research evidence reported in papers #22 and 33 in the sample, which showed significant increasing relationships. The heterogeneity associated with the hypothesis is high.

The effect of group size on satisfaction was found significant in Benbasat and Lim (1993), but insignificant in this study. This is due to new research evidence reported in paper #1 in the sample, which showed significant decreasing relationship that offset the increasing relationship shown in paper #8 in the sample. The statistics in Table 5 show that our conclusion is pretty stable.

Overall, the new evidence published after 1992 has changed some of the conclusions reached in McLeod (1992) and Benbasat and Lim (1993).

6. Conclusion

Empirical work is important to evaluate the EMS performance. Due to differences in system function, research design, subject background, task type and many other contextual factors, however, results from EMS laboratory experiments are often inconsistent. In this study, we have applied qualitative and quantitative analyses to integrate inconsistent findings into an overall understanding of the effects contextual variables (anonymity, EMS use, facilitator, group size, leadership, proximity) impose on group processes and outcomes. Our findings have also been compared with existing meta-research to reach a more reliable consensus.

Since the validity of meta-research relies heavily on the validity of the primary research it analyzes, the conclusions found in this paper still has risks and may be reversed if adequate number of opposite evidences are observed. The current findings, however, do represent the best we can find by now. They can be useful for both practitioners and researchers interested in using EMS to improve meeting productivity.

In addition, this study also identifies several potential areas for future research. They are (1) the effect of anonymity on decision time; (2) the effect of facilitators on equality, decision time, productivity, and satisfaction; (3) the effect of group size on decision time and consensus; (4) the effect of leadership on decision time and productivity; (5) the effect of proximity on decision time. For most of them, we do have adequate data to make conclusions.

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Appendix 1: Studies Included in the Sample

(Notes: The papers preceded by * are not available for quantitative analysis)

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Appendix B: Statistics for Meta-Analytic Calculations

(These indicators are adopted from Wolf (1986), which are used to investigate the strength of relationships between control variables and EMS performance)

Statistics	Description	Formula
d_u	The weighted, unbiased estimate of effect size (It is the degree to which the null hypothesis of no relationship between the independent variable and the dependent variable is false.)	$(\Sigma w_i d_i)/\Sigma w_i$ where: $w_i=(2N_i)/8+d_i^2$ N_i=sample size of study i
Z_c	Winer's statistical test (It provides a summary index of the statistical significance of the results pertaining to a hypothesis.)	$(\Sigma t_i)/\sqrt{\Sigma(df_i/df_i-2)}$
χ^2	Homogeneity test of effect size (If a series of independent studies provide a homogeneous estimate of the population effect size, then it is more likely that the various studies are testing the same hypothesis.)	$\Sigma(w_i(d_i- d_u)^2)$
$N_{fs.1}$	The fail-safe N (It shows the number of additional studies having a zero effect that would be required to lower the observed mean effect size value to a prespecified small value)	$(K(d_u- d_c))/ d_c$ where: K=number of findings in meta-analysis