An Inspire ENS Graph is Worth 334 Words, on Average

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Abstract

Electronic negotiations are supported by a number of technologies including e-mail, web-enabled decision support systems and e-negotiation systems (ENSs). The features of the ENS used by a negotiator can affect the negotiation outcome because of the type and scope of support provided and its presentation. ENSs usually interface with users via a natural language system and/or graphical display. This paper reports the results of the effect of the provision of graphical representation on reaching agreement in bilateral negotiation using the Inspire ENS system compared to negotiations conducted using the same system without graphical representation. No difference was observed in the proportion of dyads that reached agreement with graphical representation compared to the system without graphical support. For dyads that reached agreement, participants using the system without graphical support submitted a lower number of offers. The average message size per dyad was 334 words greater, on average, for successful negotiations without graphical support, although the number of messages exchanged by the negotiators was not significantly different. The incongruence between the information presentation format and the negotiation task is thought to require more extensive textual explanation of positional and offer rationalization to compensate for the lack of graphical support.

1. Introduction

Negotiation is a key component in e-commerce. With the rapid growth of the Internet, increasing use of electronic business transactions, information overload, and human cognitive limitations, the need for negotiation support has increased. Market transactions in the electronic forum consist of three phases: the information phase where customer and supplier find each other, the contract negotiation phase where offers are made and settlement terms agreed upon, and the settlement or fulfilment phase where the agreed terms are fulfilled (Kersten 1988; Weigand, De Moor et al. 2003).

E-negotiation systems (ENSs) are designed to assist negotiators in reaching mutually satisfactory decisions by providing communication and decision models to aid in requirement and strategy analysis functions (Lim 2000). They provide assistance for problem-solving, consensus seeking and conflict resolution (Jelassi and Foroughi 1989; Lim 2000). ENSs are able to improve the quality of negotiation outcomes by providing the negotiator with communication services, tools for content and version management, and decision analytic tools (Rangaswamy and Shell 1997; Schoop and Quix 2001; De Moor and Weigand 2004). Without support, negotiating parties often fail to reach efficient agreements, require longer time, or cannot engage in the process because of their physical distance.

In many negotiation situations the parties do not have complete knowledge of the set of feasible alternatives. They attempt to learn this information and also their counterparts' objectives and limitations by negotiating. Both may be exceedingly difficult if problems have many thousand alternatives and the parties have multiple objectives. By reducing the demands for information search, assessment, and processing of information for the participants, ENSs can play a significant role in value creation in a negotiation (Kersten 2001). They may both simplify and enrich assessment of negotiation artifacts such as alternatives, offers and concessions. Simplification may be achieved by presenting said artifacts in a highly structured and organized manner; enrichment may be achieved when the same artifact is presented to the user in several different ways, e.g., in the form of free text, structured text, simple icons and graphs. These different forms of representation are incorporated into ENSs in order to improve human cognitive performance and communication.

ENSs functionality ranges from specialized expert systems which help negotiators prepare for a negotiation, to mediation and interactive negotiation systems which aid the problem and/or process structuring activities (Rangaswamy and Shell 1997; Kersten and Noronha 1998; Schoop, Jertila et al. 2003; De Moor and Weigand 2004). Recognition of human cognitive limitations has been the basis for the evolution of negotiation approaches from being considered a "pure art" to a more rational, knowledge-based approach proposed by negotiation analysis (Raiffa 1982; Young 1991; Sebenius 1992).

In a negotiation, positional comparisons and assessments are required in order to determine if an offer made by the other party meets the persons' requirements and should be accepted. Positional comparisons are considered spatial tasks, and are easier for humans to accomplish when in a form having cognitive fit and that allows parallel processing (Vessey and Galletta 1991). By using an appropriate representation of the task it is easier to construct a mental model and make a decision concerning offer acceptance or rejection (Zachary 1986; Larkin and Simon 1987). An added benefit of using an appropriate representation may be a reduction in cognitive load, freeing cognitive resources and reducing problem-solving effort of the negotiating parties (Lohse 1997).

During a negotiation, offers are compared against the negotiator's aspirations, reservation levels or the best alternative to the negotiated agreement (Fisher and Ury 1981; Raiffa 1982). This posits that the most effective method to perform this comparison is using a graphical aid. The use of graphical representation requires data which is not commonly available in traditional negotiations. Information and communication technology makes production of this data easier but not mandatory.

E-negotiations which conducted via email became common and have been studied extensively (Croson 1999; Purdy and Neye 2000; Thompson and Nadler 2002). With the exception of the most simple case, i.e., single and quantifiable issue, email negotiations do not allow for the construction of graphs. Production of data for multi-issue negotiations requires the use of support tools and additional effort from their users. The question is whether this effort is worthwhile, whether the graphs constructed from the data play a role in the negotiation process and/or outcomes. To our knowledge, no study has been conducted which compared the effect of graphical display within an ENS on the process and outcomes of negotiations. This paper reports results of such a study. Section 2 briefly discusses graphical representation aids focusing on their applicability to the negotiation process. Section 3 describes the Inspire negotiations and the Inspire ENS system. Section 4 explains the research hypotheses and methodology, with the results and data analysis presented in section 5. These results are discussed in section 6, with the final sections encompassing conclusion, research limitations and future research.

2. Decision aids

Mental representations of problems are dynamic as new information is incorporated and old information updated or deleted. They can be shared with others through a variety of interactive processes including verbal and written communication. When interacting, miscommunication frequently occurs resulting in reduced, incorrect, or misinterpreted knowledge. This can affect a person's ability to effectively solve problems.

Representational decision aids have been used successfully to help overcome mental resource limitations and extend human processing abilities by efficiently and accurately representing and communicating problem perspectives (Larkin and Simon 1987; Vessey 1991). This section first gives an overview of representation aids. It then presents a brief literature review of graphical representations and cognitive fit.

2.1 Representation aids

Representation aids are interfaces providing a method to present the problem customized to the needs and capabilities of human cognitive processes and are of the following three types (Zachary 1986):

1. Natural communication aids allow a person to interact with the system in a manner which is natural for this person, e.g., using natural language or a pictorial metaphor. These aids minimize the cognitive load imposed on the decision maker to construct a mental image of the problem based on the representation format provided.
2. Stylized communication aids represent the problem in a way which capitalizes on human cognitive processing ability. Humans are good at directly perceiving spatial relationships, as compared to indirectly inferring them, when presented with the appropriate visual information. Also, they can reason about relationships in spatial terms by using visual metaphors; these metaphors are provided by the stylized aids.

3. Knowledge representation aids capture the representation or mental model in a way used by experts who explain their reasoning. Rule-based models which are incorporated into a system interface are the typical example of these aids.

A mental model is a representation of a system that can be used to describe, explain, and predict future system states. Often in negotiations people see what they wish, or expect, to see due to differences in *a priori* knowledge (Swaab, Postmes et al. 2002). Individual motives also influence a person's perceptions during a negotiation. The result is that each party has a different conceptualization of the problem situation. Inconsistencies between their understanding of the problem and potential solutions may result in conflict beyond the scope of the negotiation itself. Conversely, parties having similar knowledge may recognize commonalities between them, possibly forming the basis for convergence and settlement. A shared mental model can influence negotiation outcomes by providing a common view of the problem, and potential solutions, to the negotiators.

Data visualization aids of both first and second type are easier comprehended than text. Therefore they have the potential to reduce the scope for divergent interpretation compared to textual and verbal information that is subject to miscommunication (Massey and Wallace 1996). Graphical representations may also provide a common framework to allow negotiators to directly perceive the problem space. Where a divergent cognition situation occurs, more explanation (dialogue) is expected to be required in order to convince the other party, or justify a positional stand, than would occur for common perception.

2.2 Graphical aids

The enhanced performance due to graphical aids is thought to result from the increased efficiency of acquiring and processing information. Larkin and Simon (1987) argue that diagrams improve information processing by indexing information needed to solve a problem more effectively and efficiently. Wickens (1995), states that graphs reduce cognitive load by shifting some of the information acquisition demands to our visual perception system which frees cognitive resources for use elsewhere in the problem-solving task. However, this is only assumed to result in improved decision performance if the decision-maker has capacity-constrained cognitive resources which are made available for use elsewhere in the problem-solving process (Lohse 1997).

When cognitive demands are substantially increased graphical aids reduce problem-solving effort by conserving cognitive resources allowing individuals to perform more difficult tasks than if the information was presented in a less suitable format. Lohse (1997) states that people make the same mental calculations, but differ in computation efficiency depending upon the capacity (high or low) of their working memory. The difference was especially prominent at high levels of task complexity.

The usefulness of a particular graphical display appears to be dependant upon the decision problem (Jarvenpaa 1989). The literature indicates that graphs tend to improve decision speed but not accuracy (Vessey and Galletta 1991). The benefit of a specific graphical format depends upon the relative compatibility between the task and the decision aid. Studies on the role of tabular displays in consumer information behaviour indicate that the information presentation format affects decision outcomes through the format's influence on cognitive processes (Tversky 1969; Painton and Gentry 1985).

Payne (1982) explains the effects of display format on problem-solving as a compromise between the benefits of minimizing errors and the cognitive cost (effort) in a particular task environment. The organization of information on a display affects this cost-benefit trade-off by making some strategies easier to use than others. Incongruence refers to a situation where the processing required for a decision strategy and the process encouraged by the graphical presentation format conflict (Jarvenpaa 1989).

Graphs are considered to be ’imaginistic’ (i.e., convey continuous information) while tables are verbal in nature (*i.e*., convey discrete information), (Pracht and Courtney 1988; Vessey 1991). Graphs are spatial problem representations as they present spatially related information that emphasizes information about data relationships. Tables are symbolic data representations as they present information that is symbolic in nature. Tables represent discrete data values. Graphs and tables are problem representations that emphasize different characteristics of a given data set. Spatial representations (graphs) facilitate viewing the information at a glance without addressing the elements separately or analytically. Therefore, perceptual processes provide an appropriate access to graphical data. Symbolic representations facilitate extracting specific data values. Therefore, analytical processes provide an appropriate access to the data in tables (Vessey 1991).

Decision-making tasks, such as those involving judgement and inference in a negotiation, are more complex tasks that must usually be decomposed into several subtasks. They involve both information acquisition and information evaluation. Negotiation may be considered as either a spatial or a symbolic task depending upon the type of information required. Task performance is improved when there is a cognitive fit or similarity between the information representation format and the information required by the task type (Vessey 1991).

2.3 Cognitive fit

Cognitive fit theory states that complexity in the task environment will be reduced if the problem-solving aids (tools, techniques, problem representation) directly support the task strategies (methods or processes) required to perform the task (Vessey 1991, 1991 #234). As humans are cognitively limited in terms of information processing, more effective problem solving occurs if the complexity of the task environment is minimized (Massey and Wallace 1996). This requires matching mental representation of the problem to the problem solving task.

People formulate a mental representation based on either the problem representation or the task. If the mental representation is based on the problem representation then the person needs to transform it to derive a solution; if a mental representation is formulated based on the task they need to transform the data from the problem representation into a compatible mental representation suitable for task solution (Vessey 1991). Cognitive fit encourages the use of consistent (optimal) problem-solving processes in task solution, resulting in improved performance (Vessey and Galletta 1991). More recently the examination of cognitive fit theory has been extended to judgment theory (Tuttle and Kershaw 2001). Their results suggest that graphical displays should improve judgment where holistic decision making is used.

In ENS-supported negotiations, the most straightforward way to compare multi-issue offers and assess the negotiation progress is to present their utility values to the negotiators. This involves analyzing the utility of not only the current offer, but also the utility of all past offers in the negotiation. It is our position that this type of relational information is best represented in a graphical format. According to Fry (1981), “Graphs… tend to show the ‘big picture’ or gestalt… Often interrelationships can be seen better with a graph than with a purely verbal or numerical presentation.” This is consistent with other research in which relational information data represented in graphical form was considered superior to that in tabular form (Coll, Coll et al. 1994). Umanath and Scammell (1988) report the graphical representation has much higher recall of directional order and pattern recall than tabular representation.

3. Inspire negotiations and their modes

The following sections describe the Inspire ENS and the negotiations conducted using the unaltered system and the system without graphical representation. Examples from actual negotiations of graph and tabular components are shown.

3.1 Inspire negotiations

This study involved a comparison of multi-issue bilateral negotiation using two variations of the Inspire ENS (Kersten and Noronha 1998; Kersten and Noronha 1999). The system is used to conduct negotiation simulations with their main characteristics resembling a real negotiation. Mainly, Inspire users are assigned the Cypress-Itex case which describes a bicycle-parts purchasing problem. Buyers represent Cypress Cycles, a firm that assembles and sells bicycles; sellers represent Itex Manufacturing, a manufacturer of bicycle parts. Participants are asked to reach agreement on four different issues: the price of the bicycle components, delivery schedules, payment terms, and defective parts return. They make their own decisions regarding preferences, strategies, and tactics.

Inspire organizes the negotiation into several phases, each comprising well-defined activities:

1. Pre-negotiation during which the parties read the case material and undertake activities leading to the construction of a value function.
2. Negotiation during which the parties construct offers and exchange them; this phase ends—if successful—when a compromise agreement is achieved.
3. The post-settlement phase occurs only if agreement is achieved and it is inefficient; the system suggest efficient improvements and the users may engage in agreement re-negotiation.

The construction of the value function involves individual rating of the four negotiation issues and options for each issue. The importance of each issue relative to the other issues is determined solely by each Inspire user. The system employs hybrid-conjoint analysis to construct the value function which represents the user’s preferences (Kersten and Noronha 1999).

During the negotiation, support for offer construction and counteroffer evaluation includes offer ratings based on the individual value function. At any time the negotiation progress can be assessed by viewing a chronological graphical display showing the users' ratings of offers sent and received. This display involves a graph and following it the transcript of all offers and messages. An example of the negotiation history is given in Figure 1, showing negotiations between Chris and Tamara as seen by Chris. The graph “History of Offers” shows a negotiation timeline with offers indicated by their ratings; both Tamara’s and Chris’s ratings are obtained from Chris’s value function (this is stated in the explanation given below).

Following the graph (and explanation) are two offers with accompanied messages. Offer no 6 (at the bottom of Figure 1) was the last offer submitted by Chris. Tamara, Chris’s counterpart, accepted this offer and also attached a message to it. Under each offer the offer rating is given.

The graphical display, called History of Offers (Figure 1) shows the distance (determined by the user value function) between the offers submitted and the offers received (i.e., it shows how far apart the two sides are).

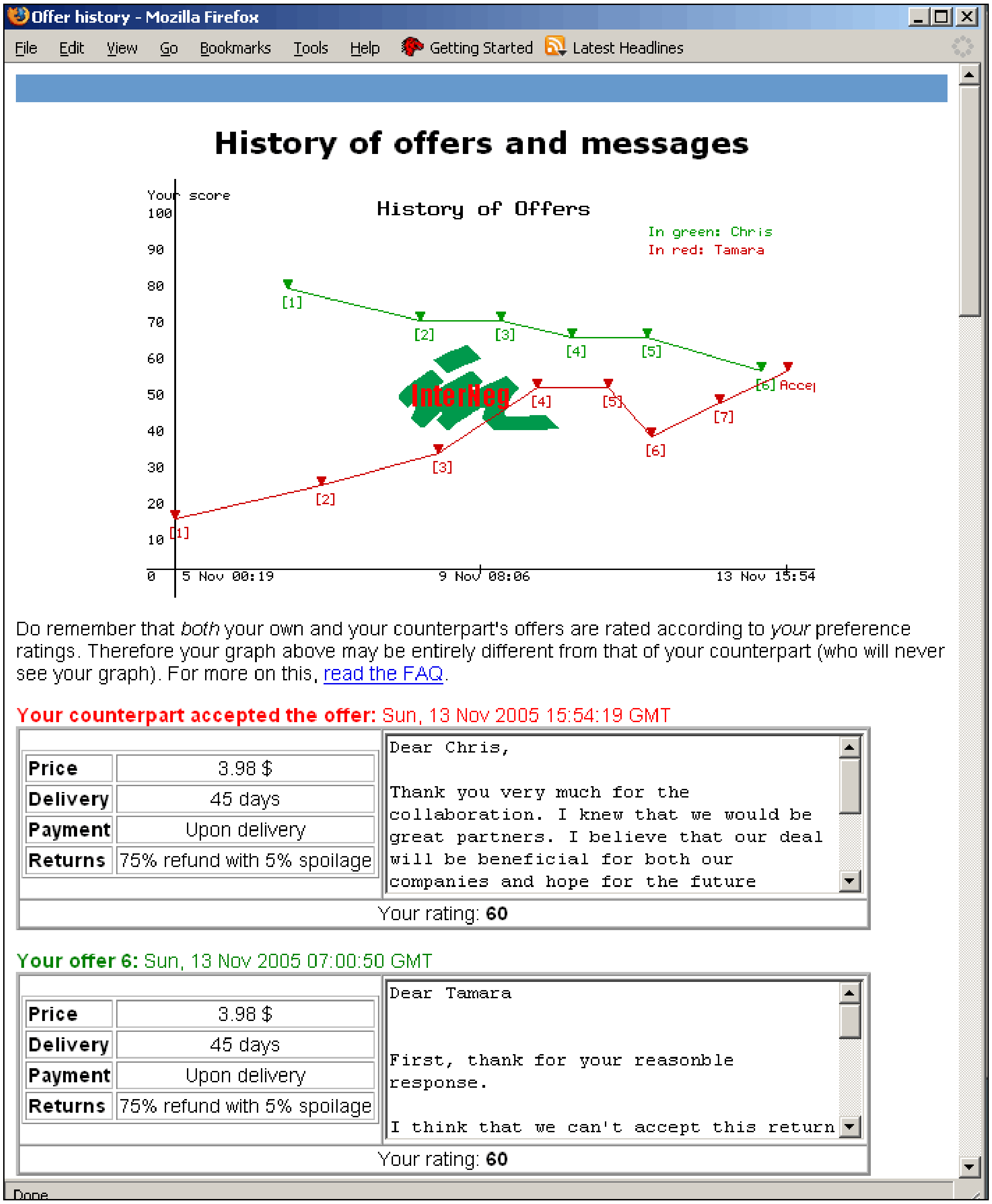

Figure 1: History of offers and messages for Chris and Tamara

To indicate the importance of the graphical representation of Inspire negotiation and the fact that the user's rating are used in graph construction we compare graphs of two users in the same negotiation. Figure 2(a) shows the history of offers from the perspective of Chris (representing the buyer); Figure 2(b) shows the history of offers from the perspective of Tamara (representing the seller). Convergence, and a compromise agreement, occurs after several iterations of offer-counter-offer.

3.2 Two modes

The experimental system was the same as for the full model described above with the exception that the graphical display (Figures 1 and 2) was turned off for both parties (buyer and seller); all other features functioned normally and the same as for the full model. No indication was given to either party that system functionality had been altered. Each party was able to know the value of their position (offer) from the tabular display (Figure 3), but was unable to know the relative distance between offers sent and offers received by viewing the graphical display.

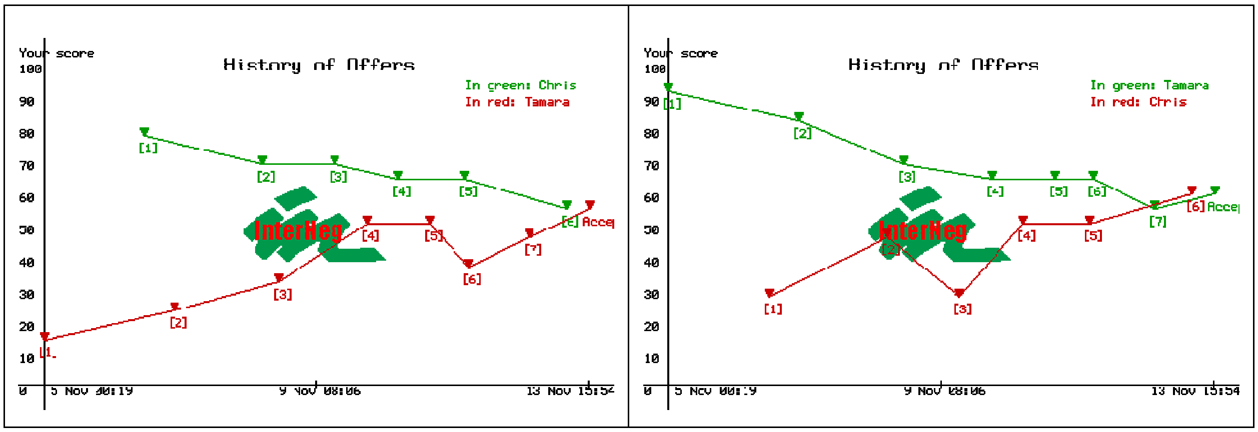

Figure 2: History of offers (a) Chris's, and (b) Tamara's

4. Hypotheses and research methodology

The specific comparison is between the Inspire ENS with grapical support enabled and the same system with the graphical support function disabled. The experimental research hypotheses, participants, and research methodology are given in the following sections.

4.1 Hypotheses

During a negotiation, positional comparisons are required in order to construct, defend and modify reservation and utility values. Deciding if an offer should be accepted or rejected is best determined by comparison of the utility values of the offers relative the anchor point chosen by each individual. The most efficient method to perform this relational comparison is through a graphical decision aid (Fry 1981; Coll, Coll et al. 1994). By improving the ability of a negotiator to acquire, interpret, and compare a time series of relative utility values, each negotiator should possess an 'informed' and 'accurate' set of knowledge in which to make their offer construction, acceptance or rejection decision. Given 'informed' and 'accurate' knowledge, negotiators are more likely to reach agreement. It is therefore hypothesized that the provision of graphical representation in an ENS will improve the number of dyads reaching agreement compared to an ENS lacking this aid.

H1. Providing graphical support will increase the number of dyads reaching agreement.

Graphical support is expected to reduce cognitive load and problem-solving effort for offer formulation and evaluation in a negotiation situation. Offer construction and counteroffer evaluation for the Inspire ENS are given via ratings based on the utility function for each party, and is expected to be more cognitively challenging to evaluate without graphical support. Where information equivalence exists, computational efficiency depends on the data structure (Larkin and Simon 1987). A cognitively intense problem requires more effort to search the data, recognize and extract relevant information, and draw inferences (Simon 1978). Incongruence between the presentation format and the decision strategy must invoke a cost, such as increased time (effort), reduced accuracy (error), or both (Jarvenpaa 1989).

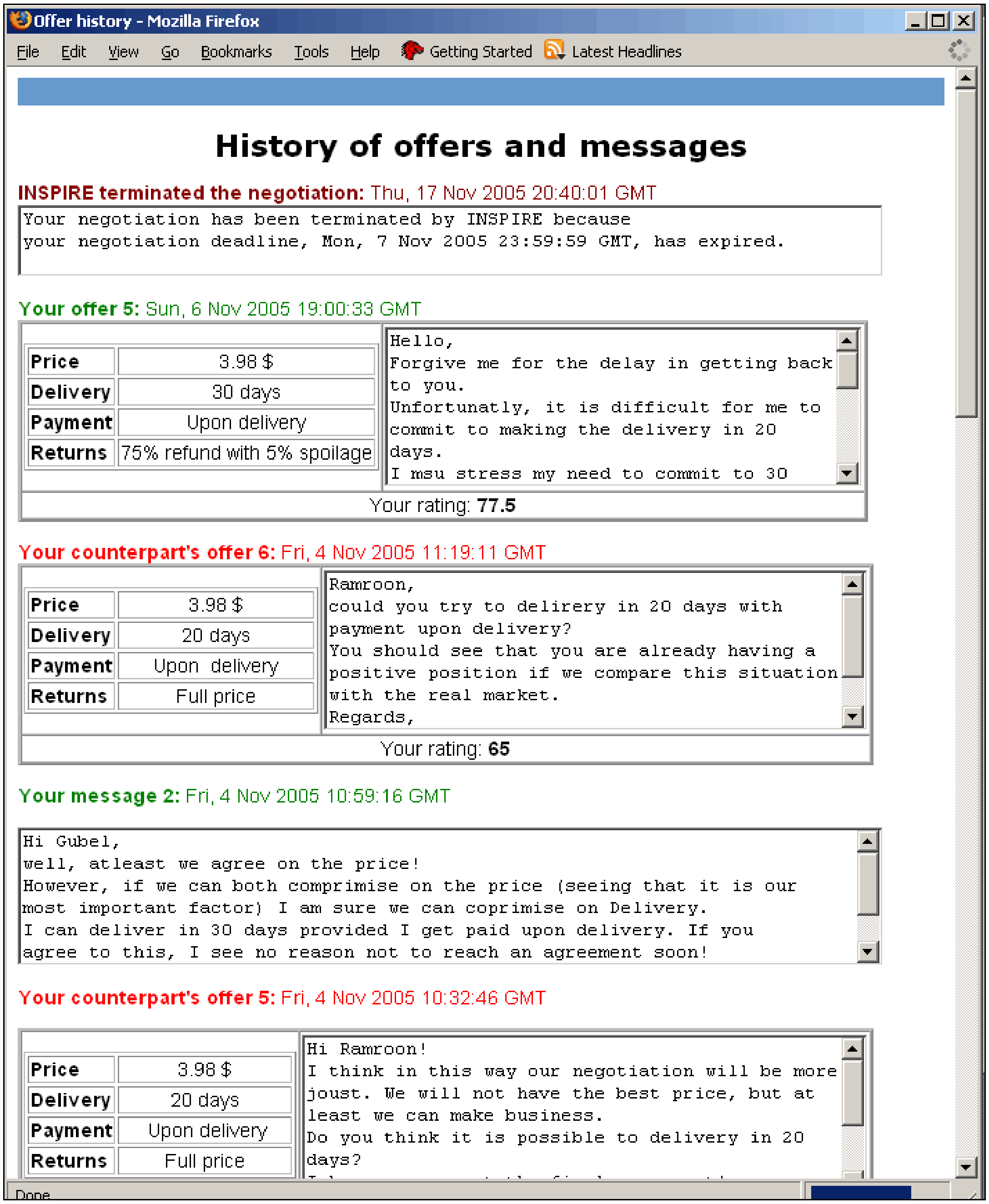

Figure 3: No-graph display of the negotiation history

Without graphical support, these effects are expected to make the offer-counter-offer process lengthier or less efficient and therefore require a greater number of offer-counteroffer iterations to reach agreement. For dyads reaching agreement, graphical representation is expected to reduce the number of offers required to reach agreement compared to dyads without graphical support.[1]

H2. Providing graphical support will reduce the number of offers required to reach agreement.

As the provision of graphical support is expected to make positional comparisons clearer, reduce cognitive load, and provide a shared model accessible to both parties it is expected that less positional explanation and rationalization (textual communication) will be required by the participants to reach agreement.

H3. Dyads with graphical support will require less textual communication to reach agreement.

4.2 Methods

The experimental comparison is between the experimental model without graphical support and the full model with graphical support (control). Participants are randomly designated as either a buyer or a seller of bicycle parts and conducted the negotiation by logging in to the Inspire ENS system. Other than the case material specific to their role, no direction was given during the negotiation. Each party chose their own preferences, limits, strategies, and goals. No training was given to any of the participants, although resource material (glossary, frequently asked questions, and a simplified (two issue) example not related to the negotiation case) was available on the InterNeg web site (http://interneg.org/inspire).

Table 1: Pre-negotiation self-identification of occupation

Occupation	Percentage of participants	
	Graph model	No-graph model
Student	56.6	64.2
Professional	16.9	30.2
Undefined	22.7	5.7
Other	0.04	0.0
Negotiator	< 0.00	0.0

The majority of participants (57%) self-identified as undergraduate university students, although others (*e.g.*, professionals, instructors, or interested individuals) also participated (Table 1). Of over six thousand participants, a very few self-identified as a professional negotiator (n = 4). Each participant was paired with a counterpart from another university, and often from another country. No monetary incentive was offered for participation, although some received academic credit for participation or may have used the system for negotiation training. Participation was both anonymous

[1] An offer is considered to be one submitted on all four issues (price, payment, delivery, and returns) using the ENS system as opposed to a verbal (textual) offer that might have concerned fewer than the four issues.

and voluntary; the negotiation could be discontinued by either party at any time.

Data was collected by three methods, the mandatory pre-negotiation questionnaire, the optional post-negotiation questionnaire, and automatically generated negotiation logs containing preference structures, messages, offers, and ratings. Negotiations were conducted using the no-graph model (n = 65). Results were available from ongoing negotiations using the fully functional (*i.e.*, with graphical display) model (n = 3063).

Due to unknown causes, some negotiators did not negotiate. These instances are designated as 'one side only' in the data set and were discarded from both the no-graph and full model data sets. The total number of usable cases was 54 for the no-graph model and 2353 for the full model. The large number of pre-existing cases for the full model could not be replicated for the experimental (no-graph) model due to resource and time limitations, although comparative sample sizes would have been preferable. The statistical methods used for data analysis took into account the different sample sizes by using Welch's *t*-test assuming unequal variance.

A dyad was considered to reach agreement when one of the negotiators accepts the offer of the other negotiator. The number of offers per dyad per negotiation included offers from both negotiators. Finally the amount of textual communication per dyad per negotiation was measured by the number of textual message sent by both negotiators and by the total number of words sent in all messages for both negotiators.

5. Results

As the number of cases for the full model far exceeded the number for the no-graph model, an F-test was used to determine stable variance in the data. A representative sample of data was tested; the variances of the populations the samples are from are similar. Histograms indicated normal distributions. Therefore data from the two experiments could be used to validate our hypotheses.

Demographic and case difficulty information (Table 3) was collected using the pre-negotiation questionnaire. There is not a significant difference in the proportion of females and males participating in the experiment (p = 0.77).

Table 2: Demographic and case difficulty data

	Graph model	No-graph model	Test	p value
Gender			Chi-square	
Percentage male	52.8	58.2	0.0831	0.7731
Percentage female	47.2	41.8		
Case Difficulty			t-value	
Mean	2.19	2.55	-2.56	0.0145
Issue Weighting				
Mean	2.86	2.90	-0.240	0.8118
Option Weighting				
Mean	2.98	2.95	0.206	0.8377

A significant difference in case difficulty was observed for users of the no-graph model ($\bar{x}$ = 2.55, p = 0.01) than for those using the full model ($\bar{x}$ = 2.19), although it should be noted that these responses were entered prior to either group using their respective system and that case information was identical for both models except for the buyer or seller difference. The difficulty in assigning weights to the issues (p = 0.81) and options (p = 0.84) was similar for both groups, and not significant in either instance.

5.1 Hypothesis 1: Reaching agreement

Hypothesis 1 postulates that the provision of graphical support increases the number of dyads reaching agreement.

The proportion of successful and unsuccessful (*i.e.*, the negotiation did not end with a compromise agreement) negotiations was determined for each model. The mean success rate for reaching agreement was 67.5% for the full model and 68.5% for the no-graph model (Table 4). These results are not significant (p = 0.9995). Therefore, the hypothesis that graphical support would increase the number of dyads reaching agreement is not supported.

Table 3: Proportion of negotiations reaching agreement

Reaching agreement	Graph model	No-graph model	Chi-square	p value
Success mean	67.5	68.5	3.52×10^{-7}	0.9995
Fail mean	32.5	31.5		

5.2 Hypothesis 2: Reduction of offer number

Hypothesis 2 postulates that the provision of graphical support reduces the number of offers required to reach agreement.

The number of formal offers made by each side was determined for users of the full and no-graph model that reached agreement (Table 5).

Table 4: Number of offers submitted for dyads reaching agreement

Offers submitted	Graph model	No-graph model	t-value	p value
Mean	8.7	8.0	1.99	0.0541
Minimum	2	4		
Maximum	37	16		
Median	8	8		
Mode	8	6		
Standard deviation	3.65	2.36		
Variance	13.35	5.64		

The mean number of offers submitted was 8.7 for the full model and 8.0 for the no-graph model. These values were marginally significant (p = 0.0541) although contrary to the hypothesis as more offers were submitted to reach agreement using the full model. The median number of offers (n = 8) was the same for both models. The most frequent number of offers (mode) was higher for the full model (n = 8) than the no-graph model (n = 6). The minimum number of offers submitted to reach agreement was twice as many for the no-graph (n = 4) as the full model (n = 2). The opposite situation occurred in terms of the maximum number of offers with more than twice as many being submitted for the full model (n = 37) as the no-graph model (n = 16). Overall, fewer offers were submitted to reach agreement using the no-graph model although the minimum number was twice as many. Both mode and the maximum number of offers submitted were lower for the no-graph model.

5.3 Hypothesis 3: Communication amount

Hypothesis 2 postulates that dyads which have graphical support require less communication to reach agreement.

Successful negotiations sent approximately the same number of messages for both models (4.1 vs. 4.2 messages), but the number of messages sent by users of the no-graph model who did not reach agreement was much lower (3.4 messages) (Table 6). The average number of messages transmitted between the negotiators is higher for successful negotiations compared to failed negotiations for both models. The maximum number of messages is much higher for the full model than the no-graph model, although the median number of messages is higher for the no-graph model (n=4) compared to the full model (n=3) (Table 6). Dyads reaching agreement had a higher mode for the no-graph model (n=5) than did those using the full model (n=2). Within model comparisons indicate that there is not a significant difference in the number of messages transmitted for the full model (p = 0.1689) but is a marginally significant difference for the no-graph model (p = 0.0701) (Table 6).

Table 5: Messages submitted for each model

Messages	Full Model		No-graph Model	
	Success	Fail	Success	Fail
Mean	4.1	3.9	4.2	3.4
Minimum	1	1	1	1
Maximum	52	22	12	8
Median	3	3	4	4
Mode	2	2	5	1
Variance	16.4	7.8	5.1	4.4
t-stat	1.376		1.840	
df	1853		69	
p value	0.1689		0.0701	

Considerable differences are evident in the message size between the full and no-graph models (Table 7). The mean total message size word count per dyad (this includes the sum of all messages for both negotiators over the course of the negotiation) is more than six times greater for successful negotiations for users of the no-graph model (n = 393.6) compared to the full model (n = 60.0). This value decreases slightly for users of the full model (n = 58) and the no-graph model (n=266.2) not reaching agreement, but is still more than four times higher for the latter group (Table 7).

The number of words per message is also much higher for the no-graph model than the full model for both successful (60.6 vs. 93.0) and unsuccessful (57.8 vs. 78.0) negotiations. Note that the many instances of no words being exchanged in the successful full model negotiations accounts for the fact that the mean word per message count for the same treatment (60.6) is actually higher than the total mean word count across all messages (60). Within model comparisons indicate that there is not a significant difference in the total message size per dyad for the full model (p = 0.2007) but is a significant difference for the no-graph model (p = 0.0155) (Table 7).

Table 6: Dyadic message size for each model

Total Message Size	Full Model		No-graph Model	
	Success	Fail	Success	Fail
Mean Words	60.0	58.0	393.6	266.2
Minimum	0	0	93	0
Maximum	825	519	1538	1053
Median	41	41	335	206
Mode	23	15	137	24
Variance	4001	3111	56404	63051
t-stat	-1.280		-2.491	
df	5988		61	
p value	0.2007		0.0155	
Mean words per message	60.6	57.8	93.0	78.0

Table 7: Between model comparison of messages and word count

	Full vs. No-graph Model	
	Success	Fail
Messages		
t stat	-0.330	1.37
df	102	39
p value	0.7422	0.1795
Total message size per dyad		
t stat	-12.087	-4.834
df	73	33
p value	<<0.0000	<<.0000

Comparison between models (Table 8) indicates no significant difference in the number of messages for those dyads reaching agreement (p = 0.7422) or those that failed to reach agreement (p = 0.1795). The total message size per dyad is significantly different for both unsuccessful and successful negotiations (p <<0.0000). Although there does not appear to be a difference in terms of the number of messages sent between the models, the message size is significantly larger for the no-graph model regardless of the negotiation outcome (Table 8).

6. Discussion

Similar proportions of dyads reached agreement for both the full and no-graph models (Table 4), approximately 68% for both. For the pre-negotiation questionnaire, prior to either model being used by the negotiator, the no-graph respondents reported more difficulty ($\bar{x}$ = 2.55) in comprehending the case than those assigned to the full model ($\bar{x}$ = 2.19); this difference was significant (p = 0.0145) (Table 3). The reason for this difference is unknown, but may reflect a comprehension difficulty for those assigned to the no-graph model, a lower English proficiency[2], or be an artefact. That this result could be an artefact is probable as no difference in issue weighting (Table 3), option weighting (Table 3), or the proportion of cases reaching agreement was observed (Table 4).

The hypothesis that graphical support would increase the number of dyads reaching agreement was not supported. It was postulated that the provision of graphical support would decrease the cognitive load for individuals and/or improve cognitive performance (Larkin and Simon 1987), thus allowing dyads to reach more efficient, and more frequent, agreement. As there was no observed difference in the frequency of reaching agreement (Table 4), graphical representation did not improve dyadic negotiation performance.

The graphical information provided to full model users was the same information provided in tabular form to no-graph users. Given sufficient time, a negotiator could eventually arrive at the same decision result (computational equivalence) as one using graphical support even though the representation format is not informationally equivalent. As decision speed was not determined, it is not know if there was a decision time benefit for users of the full model compared to those using the no-graph model as was found by Jarvenpaa (1989) and Vessey and Galletta (1991). If the decision process is capacity-constrained due to cognitive load limitations, graphical support would be expected to improve performance. No difference in negotiation success was observed between the two models (Table 4). This negotiation encompasses four issues and has only a limited number of offers to select from. For more complex negotiations with a greater numbers of issues being negotiated simultaneously, cognitive capacity constraints might be more subject to improvement by the provision of ENS graphical support. It is also unknown if differences in individual cognitive constraints or cognitive load affected the outcome.

The proportion of females and males was not statistically different (Table 3), although the proportion of males was higher for the no-graph model (58.2%) than the full model (52.8%). Kersten and Zhang (2003) found that males have more difficulty reaching agreement than females; Ulijn and Lincke (2004) state that males tend to be more competitive in a CMC setting while females tend to be cooperative. With a higher proportion of males using the no-graph model gender dominance may have affected the proportion of negotiations reaching agreement. Although the difference is not quantified, Kersten and Zhang (2003) state that the effect was not large. As there was not a significant gender

[2] All negotiation information, and the negotiations, were conducted in English.

difference in the sample for either model, it seems unlikely that a gender difference would affect the proportion of dyads reaching agreement.

Users of the no-graph model submitted fewer offers on average ($\bar{x}$ = 8.0) than users of the full model ($\bar{x}$ = 8.7) (Table 5). This was found to be marginally significant (p = 0.0541). As all negotiations were allowed the same amount of time, it is reasonable to assume that equal numbers of offers could be expected for both models. That there was a difference, and that the mode differed by 25%, implies that ENS graphical representation allows offers to be formulated by the user more quickly. This could be due to the representation aid allowing the user to determine the relative value of each offer in the negotiation space without the necessity of lengthy, and time consuming, mental calculations. As negotiations generally involve incremental positional changes in a learning situation (Cross 1977; Gulliver 1979), any assistance provided to determine both trends and position relative to a reference value (*e.g.*, BATNA) should decrease the time required to formulate offers and would allow more offers in a similar time as was observed.

Communication is a necessary aspect of negotiation (Gulliver 1979; Pruitt 1981). Messages are often considered as separate from offers, and used to either rationalize the offer or convince the other party to concede (Carnevale and Pruitt 1992). Kersten and Zhang (2003) state that the number of offers exchanged influences the negotiation outcome more than the exchange of messages. Messages are presumed not to have a statistically significant impact on reaching agreement.

There was not a significant difference in the number of messages for users of the full model, but is a marginally significant effect for the no-graph model (Table 6). Message size is observed to be considerably different between the graphically supported model and the model without graphical support for those that reached agreement (message sizes of 60 and 394 words, respectively) and those that did not reach agreement (message sizes of 58 and 266 words, respectively) (Table 7). The total dyadic message size is over 300 words greater for the no-graph model than the full model with graphical support. A within model comparison is not significant for total message size for the full model (p = 0.2007), but is significant for the no-graph model (p = 0.0155) (Table 7). Average message size is also much higher for the no-graph model regardless of the negotiation outcome (Table 7).

This data may indicate that the offer formulation process is more complex, or at least lengthier, for users without graphical support. Where incongruence occurs between the problem representation and the task (*i.e.*, offer evaluation and formulation) more cognitive resources are required. For alternative processing, as opposed to attribute processing, information is processed on several attributes of a single alternative before information is processed on any other alternative. The information presentation format (*i.e.*, alternative or attribute format) dictates the processing method for the decision maker (Painton and Gentry 1985). In a multi-issue negotiation, a graphical display allows parallel evaluation of the alternative presented (the offer) on several attributes at once. This is more difficult without graphical support and, by the cost/benefit principle; this incongruence must invoke some cost, either in increased time (effort), decreased accuracy (error), or both (Jarvenpaa 1989). Either could account for fewer offers being submitted without graphical support (Table 5).

When a between model comparison of the number of messages sent for each dyad is made (Table 8), no difference is noted for successful or unsuccessful negotiations (p = 0.7422 and p = 0.1795, respectively). A similar comparison for the total message size per dyad indicates that the message size for successful (p <<0.0000) and unsuccessful (p <<0.0000) negotiations are significantly larger for no-graph users. As the number of messages is equivalent between the models, but the message size is much greater, the lack of graphical support requires greater explanation by the negotiators in order to clarify and rationalize their positions and offers and to obtain information from the other party regarding their position and preferences. The effort required to select and send a package offer using the Inspire system is much less than that required to type the large messages observed for the no-graph model (Table 7). The amount of extra text (334 words, on average) is comparable to a full page of text. It seems unlikely that this amount of effort would be expended without purpose.

Graphical support may serve as an explanatory aid bridging the cognitive gap between the negotiators. Although textual communication can also mediate, it appears to be less efficient that graphical representation. The increased amount of textual communication for users of the no-graph model (Table 7) suggests greater explanatory dialogue is required without graphical support. Although users of the no-graph model may simply be more talkative than those using the full model, or the nature of the international pairings may bring together individuals with common cultural interests, this seems an unlikely explanation for the large difference in message size. A more plausible explanation is that without graphical support more textual explanation is required in order to rationalize and convince what is immediately clear with graphical representation.

Rangaswamy and Shell (1997) found that simply using computer technology did not improve negotiation outcomes in multi-issue negotiations as compared to face-to-face negotiations. They feel that achieving integrative trades depends on maintaining high aspirations in an environment conducive to learning. High expectations provide the motivation to search for integrative trades rather than satisficing, while a problem-solving orientation provides the approach for identifying alternative proposals to offer to the other party allowing gains for both parties. Information exchange is required for these processes, and is higher for dyads without graphical support in terms of message size (Table 7). Successful negotiators seek alternatives that are satisfactory to both parties, without excessively moderating their own demands. This requires increased information exchange to explain and persuade where the lack of graphical support makes positional determination more complex. Where a negotiator sticks relentlessly to their position, and only supplies more information to justify their stand, agreement becomes less likely. No data was collected regarding positional stubbornness and repeated messages, but as similar proportions reached agreement for both models this explanation seems an unlikely explanation as positional stubbornness is not generally conducive to reaching agreement [Pruitt, 1981 #53].

Graphical representation will not necessarily affect performance over information presented in another format that is informationally equivalent. As utility values were presented in tabular form for the no-graph model, this could be considered computationally equivalent in terms of the decision-making process. The cognitive fit or information processing paradigm of Vessey and Galletta (1991), states that it is less efficient to manipulate the information but that the outcome will generally be the same. The mental representation provided by the full model ENS is more likely to have cognitive fit compared to the tabular form (no-graph model) due to incongruence between the task and the decision aid. According to Payne (1982), decision strategy selection is a deliberate compromise between the benefits of minimizing errors and the cognitive costs (effort) in a particular task environment. The organization of information on a display affects this cost-benefit trade-off by making some strategies easier to use than others. The cost/benefit principle suggests that incongruence must invoke some cost, either in increased time (effort) or in decreased accuracy (error), or both. Incongruent situations may make decision makers acquire information in the direction encouraged by the display format, but evaluate the information in the direction required by the formulated evaluation strategy. Although tabular information might be computationally equivalent, a cost in terms of decision time could occur, but not in terms of outcome as reflected in the similar proportions of dyads reaching agreement for both models (Table 4).

If the lack of graphical support resulted in longer times required to formulate decisions regarding offer acceptance and counter-offers, time constraints and deadlines would become a greater factor. Kahai (1999) empirically demonstrated a negative correlation between acceptance and agreement for group outcomes using CMC. This may indicate that the negotiator was willing to satisfice due to the impending deadline even though they were not in agreement with the settlement point. Participants using the full model made more offers than the no-graph model (Table 5), and therefore may have been less willing to satisfice as deadlines had less impact on the progress of their negotiation. Kersten and Zhang (2003) found that the majority of negotiations (approximately 70%) that continue to the deadline are unsuccessful. It is not known if this is due to impasse or the participants are still considering accepting an offer or making a counter-offer when the deadline was reached. As there was little difference in the proportion reaching agreement for either model, but was a difference in the number of offers submitted, an answer cannot be inferred from these data.

If a graph alters decision accuracy, it must have a concomitant effect not only on the efficiency of perception but also on the efficiency of some underlying cognitive information processing (Lohse 1997). Faster perceptual inferences from the graphical aid will enhance performance only if cognitive resources are capacity constrained and those cognitive resources are freed to be used elsewhere in the problem solving process. Cognitive limitations, such as working memory capacity, are not dependent on the type of graphical aid provided. A graphical aid will not automatically improve performance for complex negotiation tasks. Improved problem-solving or decision-making depends on both graphical perception and cognition. Subtle graphic design changes may alter the manner in which information is acquired and processed. Improving the manner in which we acquire information reduces the cognitive load on our working memory (processing system), which has a limited ability to store information from sequential information processing operations (Lohse 1997). This allows more cognitive resources to be devoted to task solution. Enhanced graphical design features (*e.g.*, colour or grid lines) that improve our ability to process information in parallel increase the efficiency of perceptual information acquisition tasks. By increasing the efficiency of information acquisition, designers of graphic decision aids can distribute some of the cognitive burden to perceptual information acquisition tasks and improve performance.

7. Conclusions and limitations

The hypothesis that graphical support would improve the proportion of bilateral negotiations reaching agreement was not supported, nor was a decrease in the number of offers required to reach agreement for the full model supported by the results. When considered together with the large increase in message size noted for the no-graph model (over 334 more words for successful negotiations) compared to the full model, lack of graphical support appears to require more extensive explanation (*i.e.*, more effort) of positional justification and offer rationalization in messages. There was a significant difference in the total message size per dyad between the two models The incongruence due to lack of graphical support requires more effort on the part of the negotiator, but does not appear to affect the negotiation outcome.

Although this study was not conducted in a restricted laboratory setting, as is the norm for negotiation studies, it does include some of the same restrictive features. For example, the participants were mainly students. As these individuals had no stake in the outcome (i.e., real firms were not affected by the outcome), consequences did not directly affect them as would occur in the real world. This may have reduced commitment to the negotiation task as compared to real negotiations involving superiors and principals. The range of options used for offer construction is also not reflective of a real negotiation. Limiting the possible offers to a very few choices constrains the number of offer possibilities in a way foreign to most real negotiations.

The extent the users of the full model made use of the graphical display, or if they used the graphical display, is not known. Anecdotal information indicates that the majority of users do access the graphical display feature when available, but the proportion is not known. This must therefore be considered a limitation of the study as the comparison is between graphical display users and those without.

The large difference in the number of cases for the full and no-graph models is a limitation. An equal number of cases would have been preferable, but was not possible due to time and resource constraints, and the large number of full model cases already in existence. The international nature of the Inspire system, in terms of pairings between culturally different individuals, may also be a limitation. Pairings are random depending on requests for negotiation sessions; no attempt was made in this study to determine if culture had an influence.

Timing may also have affected the performance of the participants. As the negotiations were conducted asynchronously, it is not known if attention or fatigue problems may have affected the performance of any of the participants. It is also expected that due to the three week duration of the experiment varying levels of external pressure (illness, exams, assignment deadlines, *etc*.) may have influenced individual performance by their affect on concentration.

Considering these limitations, this study contributes to the research on the use of graphical representation in ENS as it provides insight into the graphical interface use by negotiators in a real, although experimental, negotiation setting. Additionally, it examines some of the cognitive processes involved in the negotiation process.

With any computer system, familiarity and expertise of the individual user is variable. Training sessions to familiarize users with system functionality and capabilities would be beneficial prior to beginning the bilateral negotiations in order to ensure each participant has approximately equal familiarity with the Inspire ENS. Subsequent studies might use either a stratified sample or new cases of equal numbers for both systems. Cultural differences should also be taken into consideration such that pairing should be similar and not disadvantaged due to language difficulties as all negotiations are in the English language. As graphical support may reduce cognitive load in a multi-issue negotiation, determining the time required to decide on and transmit offers would be of interest. The time required to reach agreement could also be compared for the two models. A comparison of interest would be to determine if revealing individual preferences by both sides results in reaching agreement more often, or more integrative agreements. This could be accomplished by providing a graphical display of the individual issue preferences in bar graph format. This format, deconstructing the utility rating to reflect the individual issues, might also be considered for the current system.

How negotiators make use of their perceptual and cognitive capabilities to process information impacts on how, and if, they reach agreement is an area of research of benefit to the business community. Providing more efficient graphical aids for ENS in order to reduce the cognitive load on the decision maker, for example by enhancing graphical features, would aid the negotiation process. The specific features that would allow this might be the subject of further research. Specifically, what modifications would allow greater information extraction from the graphical representation? This may require combining graphical aids with artificial intelligence to allow embedded intelligence in graphics software to address the needs of individual negotiators.

References

Carnevale, P. J. and D. G. Pruitt (1992). "Negotiation and Mediation." *Annual Review of Psychology* **43**(1): 531-582.

Coll, R. A., J. H. Coll, et al. (1994). "Graphs and Tables A Four-Factor Experiment." *Communications of the ACM* **37**(4): 77-86.

Croson, R. T. (1999). "Look at Me When You Say That: An Electronic Negotiation Simulation." *Simulation and Gaming* **30**(1): 23-37.

Cross, J. G. (1977). "Negotiation as a Learning Process." *Journal of Conflict Resolution.* **21**(4): 581-606.

De Moor, A. and H. Weigand (2004). "Business Negotiation Support: Theory and Practice." *International Negotiation* **9**: 31-57.

Fisher, R. and W. Ury (1981). *Getting to Yes. Negotiating Agreement Without Giving In*. Boston, Houghton Mifflin.

Fry, E. (1981). "Graphical Literacy." *Journal of Reading* **24**(5): 389-392.

Gulliver, P. H. (1979). *Disputes and Negotiations: A Cross-Cultural Perspective*. Toronto, Ontario., Academic Press, Inc.

Jarvenpaa, S. L. (1989). "The Effect of Task Demands and Graphical Format on Information Processing Strategies." *Managment Science* **35**(3): 285-303.

Jelassi, M. and A. Foroughi (1989). "Negotiation Support Systems: An Overview of Design Issues and Existing Software." *Decision Support Systems* **5**: 167-181.

Kahai, S. and R. Cooper (1999). "The Effect of Computer-Mediated Communication on Agreement and Acceptance." *Journal of Management Information Systems* **16**(1): 165-188.

Kersten, G. (1988). "A Procedure for Negotiating Efficient and Non-efficient Compromises." *Decision Support Systems* **4**(2).

Kersten, G. (2001). "Modeling Distributive and Integrative Negotiations. Review and Revised Characterization." *Group Decision and Negotiation* **10**: 493-514.

Kersten, G. and S. Noronha (1998). "Supporting International Negotiation with a WWW-based System." *Decision Support Systems* **25**: 135-154.

Kersten, G. and G. Zhang (2003). "Mining Inspire Data for Determinants of Successful Internet Negotiations." *Central European Journal of Operations Research* **11**(3): 297-316.

Kersten, G. E. and S. J. Noronha (1999). "WWW-based Negotiation Support: Design, Implementation, and Use." *Decision Support Systems* **25**: 135-154.

Larkin, J. and H. Simon (1987). "Why a Diagram is (Sometimes) Worth 10,000 Words." *Cognitive Science* **11**: 65-100.

Lim, J. (2000). "An Experimental Investigation of the Impact of NSS and Proximity on Negotiation Otucomes." *Behaviour and Information Technology* **19**(5): 329-338.

Lohse, G. L. (1997). "The role of working memory on graphical information processing." *Behaviour & Information Technology* **16**(6): 297-308.

Massey, A. P. and W. A. Wallace (1996). "Understanding and Facilitating Group Problem Structuring and Formulation: Mental Representations, Interaction, and Representation Aids." *Decision Support Systems* **17**: 253-274.

Painton, S. and J. Gentry (1985). "Another Look at the Impact of Information Presentation." *Journal of Consumer Research* **12**: 240-244.

Payne, J. W. (1982). "Contingent Decision Behavior." *Psychological Bulletin* **92**(2): 382-402.

Pracht, W. and J. Courtney (1988). "The Effects of an Interactive Graphics-based DSS to Support Problem Structuring " *Decision Sciences* **19**(3): 598-621.

Pruitt, D. G. (1981). *Negotiation Behavior.* Toronto, Ontario., Academic Press.

Purdy, J. M. and P. Neye (2000). "The Impact of Communication Media on Negotiation Outcomes." *The International Journal of Conflict Management* **11**(2): 162-187.

Raiffa, H. (1982). *The Art and Science of Negotiation.* Cambridge, Belknap Publishing.

Rangaswamy, A. and G. R. Shell (1997). "Using Computers to Realize Joint Gains in Negotiations: Toward an "Electronic Bargaining Table." *Managment Science* **43**(8): 1147-1163.

Schoop, M., A. Jertila, et al. (2003). "Negoisst: A Negotiation Support System for Electronic Business-to-business Negotiations in E-commerce." *Data and Knowledge Engineering* **47**: 371-401.

Schoop, M. and C. Quix (2001). "DOC.COM: A Framework for Effective Negotiation Support in Electronic Marketplaces." *Computer Networks* **37**(2): 153-170.

Sebenius, J. K. (1992). "Negotiation Analysis: A Characterization and Review. ." *Management Science* **38**(1): 18-38.

Simon, H. A. (1978). *On the forms of mental representation.* Minneapolis, University of Minnesota Press.

Swaab, R., T. Postmes, et al. (2002). "Multiparty Negotiation Support: The Role of Visualization's Influence on the Development of Shared Mental Models." *Journal of Management Information Systems* **19**(1): 129-150.

Thompson, L. and J. Nadler (2002). "Negotiating via Information Technology: Theory and Application." *Journal of Social Studies* **58**(1): 109-124.

Tuttle, B. M. and R. Kershaw (2001). "Information Presentation and Judgement Strategy from a Cognitive Fit Perspective." *Journal of Information Systems.* **12**(1): 1-17.

Tversky, A. (1969). "Intrnasitivity of Preferences." *Psychological Review* **76**: 31-48.

Ulijn, J. M. and A. Lincke (2004). "The Effect of CMC and FTF on Negotiation Outcomes between R & D and Manufacturing Partners in the Supply Chain: An Anglo/Nordic/Latin Comparison." *International Negotiation* **9**: 111-140.

Umanath, N. S. and R. W. Scamell (1988). "An Experimental Evaluation of the Impact of Data Display Format on Recall Performance." *Communications of the ACM* **31**(5): 562-570.

Vessey, I. (1991). "Cognitive Fit: A Theory-Based Analysis of the Graphs Versus Tables Literature." *Decision Sciences* **22**: 219-240.

Vessey, I. and D. Galletta (1991). "Cognitive Fit: An Empirical Study of Information Acquisition." *Information Systems Research* **2**(1): 63-84.

Weigand, H., A. De Moor, et al. (2003). "B2B Negotiation Support: The Need for a Communication Perspective." *Group Decision and Negotiation* **12**: 3-29.

Wickens, C. D. and C. M. Carswell (1995). "The Proximity Compatibility Principle: Its Psychological Function and Relevance to Display Design." *Human Factors* **37**: 473-494.

Young, H. P. e., Ed. (1991). *Negotiation Analysis*. Ann Arbor, The University of Michigan Press.

Zachary, W. (1986). "A cognitively Based Functional Taxonomy of Decision Support Techniques." *Human-Computer Interaction* **2**(1): 25-63.