Improving Negotiations Through Awareness

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SUMMARY

Negotiations are an essential part of personal and professional life, and computer-support helps facilitate them as they become increasingly complex. Being aware of the priorities of the partner plays an essential role in successful negotiations. Two cognitive errors – the fixed-sum and the incompatibility error – hinder an integration of different priorities for achieving an economically beneficial outcome. Also, personality traits as well as figural intelligence and social value orientation interdependently influence the negotiator's individual outcomes in such computer-supported negotiations. Two studies were conducted for this thesis resulting in three articles. Each study with 132 participants, 66 dyads, negotiating in their roles as car seller or buyer. Priority awareness, the awareness about the priorities of the partner, is introduced as a solution approach. Non-interactive bar charts are used to facilitate such awareness without the need for special experience, training or instructions to diminish the two errors and improve different measures of negotiation performance. Performance awareness, a more detailed priority awareness, is a possible successor to the priority awareness approach and compared to it. It uses more of information and communication technologies interactive abilities with the intention to further improve negotiation outcomes and diminish the still existent incompatibility error. The actor-partner interdependence model is used for the analyzes of individual characteristics which may have a different influence on the negotiator's individual outcomes under the two approaches. Results show that the priority awareness approach improves the joint outcome and pareto efficiency without adverse effects on fairness, satisfaction and duration. The performance awareness approach, although having the capability to outperform the priority awareness approach, does not further improve joint outcome and pareto efficiency and has adverse effects on satisfaction, fairness and deceptiveness. Individual analyses show only hints for different effects for these approaches. In general, a good individual outcome of one partner seems highly dependent upon the lower emotionality, prosocial behavior and higher figural intelligence of the opposing partner. Priority awareness is a useful approach which can already be implemented in current negotiation support system. Future studies building upon the findings of this thesis are discussed.

Verhandlungen als essenzieller Bestandteil des privaten und beruflichen Lebens werden stets komplexer und erfordern daher zunehmend eine computertechnische Unterstützung. Das Bewusstsein über die Prioritäten des Partners spielt bei erfolgreichen Verhandlungen eine wesentliche Rolle. Zwei kognitive Fehler – der Fixed-Sum-Error und der Incompatibility Error – behindern eine Integration unterschiedlicher Prioritäten, um ein wirtschaftlich vorteilhaftes Ergebnis zu erzielen. Zudem beeinflussen Persönlichkeitsmerkmale sowie figurale Intelligenz und soziale Wertorientierung die gegenseitigen individuellen Ergebnisse der Verhandlungsführer in solchen computerunterstützen Verhandlungen. Zwei Studien wurden für diese Dissertation durchgeführt und in drei Artikeln verschriftlicht. Jede Studie hatte 132 Teilnehmer, 66 Dyaden, die in ihren Rollen als Autoverkäufer oder -käufer verhandelten. Priority Awareness, das Bewusstsein über die Prioritäten des Partners, wird als Lösungsansatz eingeführt. Nicht-interaktive Balkendiagramme werden verwendet, um ein solches Bewusstsein zu fördern, ohne dass spezielle Erfahrungen, Trainings oder Instruktionen erforderlich sind, um die beiden kognitiven Fehler zu verringern und verschiedene Maße des Verhandlungserfolgs zu verbessern. Performance Awareness, eine detailliertere Priority Awareness, ist ein möglicher Nachfolger für den Priority-Awareness-Ansatz und wird damit verglichen. Es werden hierbei mehr interaktive Fähigkeiten der Informations- und Kommunikationstechnologien verwendet mit der Absicht, die Verhandlungs-ergebnisse weiter zu verbessern und den noch bestehenden Incompatibility Error zu verringern. Das Actor-Partner Interdependence Model dient der Analyse individueller Merkmale, welche unter den beiden Ansätzen, unterschiedlichen Einfluss auf die individuellen Ergebnisse haben können. Die Ergebnisse zeigen, dass der Priority-Awareness-Ansatz das gemeinsame Ergebnis und die Pareto-Effizienz ohne negative Auswirkungen auf Fairness, Zufriedenheit und Dauer verbessert. Der Performance-Awareness-Ansatz, obwohl er die Fähigkeit hätte, den Priority-Awareness-Ansatz zu übertreffen, verbessert das gemeinsame Ergebnis und die Pareto Effizienz nicht weiter und hat negative Auswirkungen auf Zufriedenheit, Fairness und Täuschung. Individuelle Analysen deuten nur unterschiedliche Effekte zwischen den Ansätzen an. Im Allgemeinen hängt ein gutes individuelles Ergebnis eines Partners stark von der geringeren Emotionalität, dem prosozialen Verhalten und der höheren figuralen Intelligenz des

gegnerischen Partners ab. Priority Awareness ist ein nützlicher Ansatz, der bereits in aktueller Software zur Unterstützung von Verhandlungen umgesetzt werden kann. Zukünftige Studien, welche auf den Ergebnissen dieser Arbeit aufbauen, werden diskutiert.

LIST OF PUBLICATIONS IN THE THESIS

Accepted Papers

Kolodziej, R., Hesse, F. W., & Engelmann, T. (2016). Improving Negotiations with Bar Charts: The Advantages of Priority Awareness. *Computers in Human Behavior*, *60*, 351–360. http://doi.org/10.1016/j.chb.2016.02.079

Engelmann, T., Kozlov, M. D., **Kolodziej, R.**, & Clariana, R. B. (2014). Fostering Group Norm Development and Orientation While Creating Awareness Contents for Improving Net-Based Collaborative Problem Solving. *Computers in Human Behavior*, *37*, 298–306. http://doi.org/10.1016/j.chb.2014.04.052

Engelmann, T., **Kolodziej, R.**, & Hesse, F. W. (2014). Preventing Undesirable Effects of Mutual Trust and the Development of Skepticism in Virtual Groups by Applying the Knowledge and Information Awareness Approach. *International Journal of Computer-Supported Collaborative Learning*, *9*(2), 211–235. http://doi.org/10.1007/s11412-013-9187-y

Submitted Papers

Kolodziej, R., Sassenberg, K., Thiemann, D., & Hesse, F. W. (2016). *Priority Awareness Outperforms Performance Awareness in Negotiations*. Manuscript submitted for publication.

Kolodziej, R., & Sassenberg, K. (2016). *HEXACO Personality Traits That Shape the Individual Outcome in Computer-Supported Negotiations*. Manuscript submitted for publication.

PERSONAL CONTRIBUTION

All publications in this dissertation were made in collaboration with other researchers. The appendix C “Declaration of Personal Contribution” holds the completed official form for the relevant information about the own share.

INTRODUCTION

"Negotiation occurs whenever people cannot achieve their own goals without the cooperation of others." (Thompson, Wang, & Gunia, 2010, p. 491)

Negotiations play a major role, not only for salespersons and professional life but also for one's personal life and everyday human interaction. In business interactions the computer-supported negotiations are gaining traction, as mergers and acquisitions or trade agreements are getting more complex with multiple issues and options to be negotiated and high values at stake (Kersten & Lai, 2007). To achieve an economically beneficial agreement the negotiators have to deal with priorities if they are aware of them or not. In the case of a common business to customer or business to business negation of selling or buying a car or a whole car fleet, the seller may be interested in a high financing rate and selling many extras, and the buyer may be interested in an extended warranty and the latest multimedia system. As no side will just give in to the demands of the other without concessions from the other, the most profitable solution would therefore be to give in on less important issues and in exchange insist on more important ones. Giving in on issues that are less important and in return receiving concessions on issues that are more important is known as *integrative negotiation* (e. g. Barry & Friedman, 1998; De Dreu, Beersma, Steinel, & van Kleef, 2007). For such mutually beneficial *trade-offs* to take place, the negotiators must somehow be aware of their different priorities.

Tacitly fostering such kind of awareness in computer-supported negotiations – without previous training or additional instructions – and analyzing its influence on different measures of negotiation performance is the center of the experimental studies in the three main articles constituting this thesis (Kolodziej, Hesse, et al., 2016; Kolodziej & Sassenberg, 2016; Kolodziej, Sassenberg, et al., 2016).

The focus of this thesis does not only lie on "hard" measures of negotiation performance:

- The *joint outcome*; the sum of the individual points of both negotiators assigned to their agreement.

- The *pareto efficiency*; a numerical value between 0 and 1 that shows if there are any better agreements possible for at least one negotiation party without the other being worse of.
- The *impasse rate*; the number of aborted negotiations without agreement.
- The *duration*; the time needed to arrive at an agreement.

This thesis also takes multiple "soft" measures of negotiation performance into account, which are of equal importance and more "traditionally" psychological like *satisfaction*, *fairness* and *deception*.

The interdependence of the individual characteristics of the negotiators is also part of this thesis. Dependent of the amount of awareness and the use of information and communications technologies interactive abilities within a computer supported negotiation, the negotiators' individual characteristics may have a different influence on their individual outcome, which every negotiation party seeks to maximize. Not only are there indicators that one negotiator's personality traits, social value orientation and figural intelligence affect his or her own individual outcome, this characteristics may also affect the individual outcome of the other negotiator.

Neither where such tacit awareness approaches ever before envisioned nor examined but also investigating the negotiators' individual characteristics and their interdependence in computer supported negotiations – especially the HEXACO personality scales – is a complete novelty.

The following two sections "Priorities in Negotiations" and "Computer-Supported Negotiations" will start building up a basic understanding for to the actual studies and analyses of this thesis. First the importance of priorities in negotiations, their chances and challenges will be illuminated before explaining what the foundations of the actual priorities used in these studies are. Then follows a short presentation of computer-supported negotiations and what graphical decision aid was used within the experimental negotiations support system in this thesis.

The next section “Awareness in Negotiations” will describe the content of the two experimental studies and the first two main articles of this thesis. The terms “priority awareness” and “performance awareness” are introduced as solution approach and their operationalization and hypotheses presented in a concise way. Then, the foundation of these awareness approaches is described.

And finally, before specifying the objectives and expected output of the thesis and presenting the results and discussion, the role of individual characteristics in computer-supported negotiations are emphasized and the actor-partner interdependence model used for the analyses in the third main article of this thesis presented.

PRIORITIES IN NEGOTIATIONS

The awareness about the differences in priorities is crucial for an integrative negotiation to take place. Although an integrative negotiation is the best possible way to achieve a beneficial agreement for both, there are also other, suboptimal ways of coming to an agreement. An *equal split* – “meeting in the middle” on each issue – seems fair but in fact leads to an inferior joint outcome because the negotiation partner do not exchange concessions – lower prioritized issues against higher prioritized ones (Van der Schalk, Beersma, Van Kleef, & De Dreu, 2009). The same holds true for so called *distributive negotiations*: Although there may be more than one issue to agree upon, the negotiators tackle each issue individually and do not take the possibility of beneficial trade-offs into account (e. g. Barry & Friedman, 1998; De Dreu et al., 2007).

The non-awareness of differences in priorities has been shown to lessen the joint outcome of a negotiation. Thompson and Hastie (1990) have coined the terms *fixed-sum-error* and *incompatibility error* which are a direct result of not being aware of the others priorities. Regarding the first error, the negotiators wrongly assume that they both have the same priorities of issues, although they do not. Regarding the second error, the negotiators wrongly assume that they have different priorities of options within the issues, although they do not. These errors are also made by experienced negotiators

(Thompson, 1990) and in the case of the incompatibility error, they sometimes lead to lose-lose-agreements in which both agree on a common loss (Thompson & Hrebec, 1996).

On the other hand, multiple studies have shown that some kind of awareness about the priorities of the other negotiation party leads to a higher joint outcome. These studies relied either on the previous experience of the negotiators and their knowledge about the importance of priorities (Hyder, Prietula, & Weingart, 2000; Schei, Rognes, & Mykland, 2006; Thompson & Hastie, 1990) or on explicit instructions to think about priorities (Foroughi, Perkins, & Jelassi, 1995).

Tacitly fostering awareness about priorities – without the need for experience, training or instructions – seems to be a promising endeavor as it could improve different measures of negotiation performance. In experimental negotiation studies, the priorities are often founded in *payoff schedules* which create the core of every elaborated negotiation.

Foundation of Priorities

The foundation of priorities lies within the quantification of preferences, which rarely happens in real life negotiations but makes them evaluable: A payoff schedule, which is frequently used in experimental negotiation studies (Foo, Elfenbein, Tan, & Aik, 2004; e.g. Hyder et al., 2000; Olekalns & Smith, 2008; Thompson & Hastie, 1990; Van der Schalk et al., 2009). In this thesis, the payoff schedule of Thompson and Hastie (1990) for a car buying/selling scenario was modernized and used: Participants are given a scenario and a specific role (e. g. a potential car buyer and a seller) and they are asked to negotiate over predefined issues with multiple options.

The payoff schedule is an individual table with the issues to be negotiated and their options, which have points attached to them. The issues and options are identical for both negotiators because they are negotiating over the same thing. The attached points may differ between the negotiators because they may prefer different options. This difference in points for options leads to different priorities of issues. The goal of each

negotiator is to maximize the sum of his or her individual points. Table 1 holds a full overview of the used payoff schedule throughout this thesis.

The issues financing, extras, warranty and technology/audio can be integratively exchanged (relevant to the fixed-sum error). Color and CO_2 emission are *compatible* issues where both negotiators prioritize exactly the same option (relevant for the incompatibility error). Delivery date and price are *distributive* issues were both argue for a bigger share.

For the creation of priorities of issues only the modulus of the highest scoring option is relevant. For the issue price, the buyer's loss of the highest scoring option "24,500 €, -6000 points" is higher than for the issue delivery date the gain of the highest scoring option "1 month, 2400 points". Price would therefore be of higher priority than delivery date. Although omitted in many experimental negotiation studies, such negative point scores have a valid reason to exist because sometimes negotiators also have to agree on who loses less and not only who gains more.

Raiffa, Richardson and Metcalfe (2002, p. 214) use this approach of creating priorities by ranking the issues by the modulus of their highest scoring option in their evaluation of two-party integrative negotiations. Assigning points to options to represent different priorities is advisable because this switches the foundation of the own priorities from feeling to fact.

In real life negotiations the different parties come with their own priorities. In an experimental negotiation it would be possible to get closer to real life by letting the negotiators create their own priorities out of written descriptions. Unfortunately, this approach has been shown to lead to less priority consistent behavior where negotiators state priorities but do not behave according to them (Filzmoser, Rios, Strecker, & Vetschera, 2010). This approach also creates a huge variability in priorities between the different negotiation parties which does not allow for meaningful analyses.

Computer-supported negotiations and graphical decision aids are common for negotiations where payoff schedules – either self-made or given by the experimenter – are of importance.

Table 1

Overview of Payoff Schedule with all Issues and their Options with Attached Individual Points

Financing	Points Buyer	Points Seller	**CO_2 Emission**	Points Buyer	Points Seller	**Warranty**	Points Buyer	Points Seller	**Delivery Date**	Points Buyer	Points Seller
8 %	1600	4000	88 g/km	0	0	6 months	0	1600	5 months	0	2400
6 %	1200	3000	126 g/km	-600	-600	12 months	1000	1200	4 months	600	1800
4 %	800	2000	164 g/km	-1200	-1200	18 months	2000	800	3 months	1200	1200
2 %	400	1000	202 g/km	-1800	-1800	24 months	3000	400	2 months	1800	600
0 %	0	0	240 g/km	-2400	-2400	30 months	4000	0	1 month	2400	0
Extras	Points Buyer	Points Seller	**Technology/Audio**	Points Buyer	Points Seller	**Price**	Points Buyer	Points Seller	**Color**	Points Buyer	Points Seller
1	0	3200	None	0	800	24.500 €	-6000	0	Grey	1200	1200
2	200	2400	Audio base equipment	800	600	23.520 €	-4500	-1500	White	900	900
3	400	1600	Multimedia equipment	1600	400	22.540 €	-3000	-3000	Red	600	600
4	600	800	Multimedia equipment + car computer	2400	200	21.560 €	-1500	-4500	Black	300	300
5	800	0	Multimedia equipment + car computer + navigation	3200	0	20.580 €	0	-6000	Silver	0	0

The buyer and the seller could only see their own points during the negotiation. There were no restrictions made on the communication of the negotiators, including the sharing of any of this information.

COMPUTER-SUPPORTED NEGOTIATIONS

Decision makers are increasingly relying on negotiation support systems which facilitate communication and coordination of individual activities (Kersten & Lai, 2007). Multiple negotiation support systems exist in real life negotiation settings such as Zopaf (Andinian Inc., 2015) or Smartsettle (iCan Systems Inc., 2015) and in experimental negotiation settings such as Inspire (Kersten & Noronha, 1999) or Negoisst (Schoop, Jertila, & List, 2003), which structure the negotiation and create awareness for crucial information.

Multiple studies conducted on different negotiation support systems have confirmed the utility of these systems and their positive influence on different negotiation outcomes (Rangaswamy & Shell, 1997; Schoop et al., 2014; Weber, Kersten, & Hine, 2006).

These negotiation support systems were not only communication platforms holding relevant information for the negotiation but also made extensive use of visualizations.

Graphical Decision Aids

To support the negotiators in their decision making, graphical decision aids are often implemented in negotiation support systems (Gettinger & Koeszegi, 2012). Hence, an appropriate form of visualization could be used to foster awareness of differences in priorities.

Bar charts are used worldwide from regular newspapers to business reports to scientific articles; they therefore seem to be a good choice for fostering priority awareness as most people seem to have no problems handling them. Weber, Kersten and Hine (2006) have already discussed the potential of bar charts for such use. Rangaswamy and Shell (1997) used bar charts in their negotiation support system to visualize the own priorities of issues, but neither did they examine the specific effects of this visualization nor did they examine the effects of priority awareness. Bar charts have been shown to lead to shorter response times in information retrieval tasks (Quispel & Maes, 2014) and also to more accurate judgment of proportions than other forms of visualization (Simkin & Hastie, 1987). Additionally they lead to better comparisons of values than tables (Jacobs, 1994,

1999) and are also the advised visualization format for larger numerators (McCaffery et al., 2012).

As most people know bar charts, they seem to be a good choice for a graphical decision aid to not only tacitly foster awareness of priorities in a computer-supported negotiation (Kolodziej, Hesse, et al., 2016) but also to foster a more detailed priority awareness, named performance awareness (Kolodziej, Sassenberg, et al., 2016). When using negotiation support systems with graphical decision aids it is obvious that individual characteristics like for example the figural intelligence could have an influence on the individual outcome (Kolodziej & Sassenberg, 2016).

AWARENESS IN NEGOTIATIONS

To investigate the effects of different kinds of awareness on different measures of negotiation performance and their ability to diminish the fixed-sum and incompatibility error, an experimental negotiation support system was created. Two comprehensive experimental studies create the data basis for the three main articles of this thesis. In each of both experimental studies 132 participants negotiated in 66 dyads within a car buying/selling scenario. Both times, half of the dyads were in an experimental condition and half of the dyads in a control condition.

The following subsections summarize the ideas behind priority and performance awareness and how they were operationalized and then present the concept of awareness in which this thesis is founded.

Priority Awareness

Priority awareness is the awareness of the negotiator of their priorities. The term was formally coined by de Jong, Tuyls, Verbeeck and Roos (2008) in the context of negotiations. It is a way of making a negotiation algorithm aware of priorities and model it so as to mimic human behavior where sometimes trade-offs are made based on different priorities. Our definition replaces the algorithm with a human.

Priority awareness can be fostered in a computer-supported negotiation by presenting to the negotiators their different priorities of issues with bar charts, where the bars are larger where the priority of an issue is higher (Figure 1; the condition was compared to one without the priority awareness approach Figure 2). These bars do not change their size by the choice of different options in the negotiation. They look the same from the beginning to the end.

The main idea behind this first experiment is that if awareness about priorities created through experience (Hyder et al., 2000; Schei et al., 2006; Thompson & Hastie, 1990) or explicit instructions (Foroughi et al., 1995) could lead to integrative negations and thus improve negotiation performance, it could be possible to tacitly create such awareness with a well-known visualization, that does not require any experience , training or explicit instructions and with this reduce the fixed-sum and incompatibility error and also improve negotiation performance.

The hypotheses and research questions for this experiment are:

H1: *Dyads negotiating with available priority awareness agree on a higher joint outcome than dyads negotiating without priority awareness.*

H2: *Dyads negotiating with available priority awareness achieve a higher pareto efficiency than dyads negotiating without priority awareness.*

H3: *Dyads negotiating with available priority awareness arrive at a lower impasse rate than dyads negotiating without priority awareness.*

RQ1a/b: *How does priority awareness affect the objective and subjective fairness of the agreement?*

RQ2: *How does priority awareness affect the satisfaction with the negotiation?*

RQ3: *How does priority awareness affect the duration of the negotiation?*

Figure 1. Negotiation screen with graphical decision aid using the priority awareness approach (as seen by the seller).

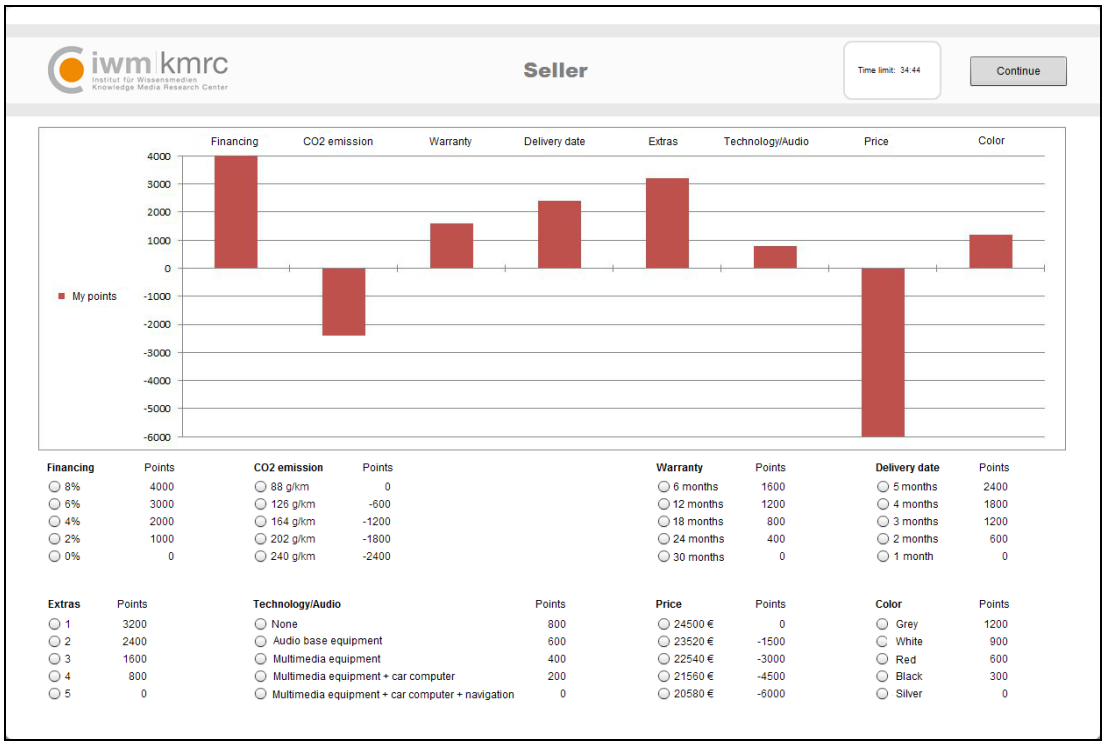

Figure 2. Negotiation screen with graphical decision aid without priority awareness approach (as seen by the seller).

Performance Awareness

Performance awareness is the awareness of the negotiator about the state of their current performance. In learning sciences this term is either understood as the quality of the estimation of performance accomplished in a learning setting (Hershey & Wilson, 1997; Pressley & Ghatala, 1988; Sağlam, 2010) or the monitoring of the current performance in a learning setting (Chen, Liu, Ou, & Lin, 2001; Devolder, Brigham, & Pressley, 1990; Wade & Reynolds, 1989). It is likewise relevant for negotiations.

Performance awareness can be fostered in a computer-supported negotiation by presenting to the negotiators their different priorities of issues and different priorities of options with transparent bar charts (Figure 3; this condition was compared to the already presented priority awareness approach Figure 4). The bars here are at first only indicated by horizontal lines where the outermost horizontal lines represent the priorities of issues. The other horizontal lines represent the priorities of options which fill up to bars, dependent on the chosen options. These bars change in size during the process of the negotiation.

Figure 3. Negotiation screen with graphical decision aid using the performance awareness approach (as seen by the seller).

Figure 4. Negotiation screen with graphical decision aid using the priority awareness approach (as seen by the seller).

The main idea behind this second experiment is to further build upon the findings of the previous study. If the priority awareness approach with its non-interactive bar charts could diminish the fixed-sum but not the incompatibility error and still improve negotiation performance, an interactive approach using more of information and communication technology's abilities could also diminish the incompatibility error and even further improve different measures of negotiation performance. Performance awareness has the potential to outperform priority awareness in making more detailed awareness information available, but interactivity and more awareness do not automatically equal better outcomes. The cognitive load theory (Chandler & Sweller, 1991), the regret theory (Bell, 1982; Loomes & Sugden, 1982), and the need for strategic misrepresentation (Steinel & De Dreu, 2004) give reason to assume negative effects and a limit to the effectiveness of awareness in negotiations.

Because of these uncertainties, the hypotheses for this experiment are all undirected:

H1: *Dyads negotiating with available priority awareness differ in the economic outcome measures of the negotiation from dyads negotiating with available performance awareness.*

H2: *Dyads negotiating with available priority awareness differ in their satisfaction with the negotiation and their partner from dyads negotiating with available performance awareness.*

H3: *Dyads negotiating with available priority awareness differ in the fairness of the negotiation from dyads negotiating with available performance awareness.*

H4: *Dyads negotiating with available priority awareness differ in their practiced and perceived deceitfulness during the negotiation from dyads negotiating with available performance awareness.*

H5: *Dyads negotiating with available priority awareness differ in how they deal with information for future negotiations from dyads negotiating with available performance awareness.*

Foundation of Awareness

The idea of fostering these kind of awareness originated in the knowledge and information awareness approach which was part of the two side articles of this thesis (Engelmann, Kolodziej, et al., 2014; Engelmann, Kozlov, et al., 2014).

Knowledge and information awareness is defined as the awareness of group members' about what the other members know about and where they know it about from. It was shown in multiple studies that implicitly fostering knowledge and information awareness in computer-supported work groups, enhanced the effectiveness and efficiency of their solution to a complex problem (Engelmann & Hesse, 2010; Engelmann, Tergan, & Hesse, 2010; Schreiber & Engelmann, 2010). It also guided their communication (Dehler, Bodemer, Buder, & Hesse, 2011) and increased the discussion and processing of unshared information (Engelmann & Hesse, 2011). This approach reduced the undesirable effect of too much trust between the group members in such tasks in which they would not question the decisions of the others and achieve an inferior result (Engelmann, Kolodziej, et al., 2014). It was possible to implicitly foster the development of a group norm facilitating the creation of the concept maps responsible for the knowledge and information awareness: The group members were given the possibility to watch each other in the creation of their concept maps, which in turn fostered knowledge and information awareness and improved their collaborative problem solving (Engelmann, Kozlov, et al., 2014)

The adaptation of such an awareness approach to a more organizational context, specifically negotiations, seemed promising. Creating awareness in a computer-supported negotiation, *nudging* the negotiators to engage in integrative negotiation (Thaler & Sunstein, 2009), *signaling* differences in priorities (Spence, 1973) by *highlighting* priorities in bar charts (Richter, Scheiter, & Eitel, 2016; Van Gog, 2014) could show similar results like the aforementioned knowledge and information awareness approach. Although the method of creating awareness differs between the approaches – concept maps and bar charts – the implicit nature of facilitating awareness stays the same. Contrary to the scripting approach, which explicitly structures the interactive processes between two parties in collaboration scripts (Kollar, Fischer, & Hesse, 2006), there are no explicit

instructions on how to use the graphical decision aid in a negotiation. There is no information about its benefits for the negotiators and there is no training in how to make use of it for integrative negotiations. There are different psychological steps involved in creating priority or performance awareness (Table 2): It is dependent on the negotiators perceiving the bar chart per se before understanding that it is about differences in priorities, and finally interpreting it accordingly, using this information to beneficially integrate their different priorities. The mere visualization of priority information – or more detailed priority information which creates performance awareness – should be enough to foster awareness and improve different measures of negotiation performance.

Table 2

Psychological Steps Involved in the Effectiveness of Methods of Creating Awareness

Step	Description	Example for this Thesis
1 Perception	The method of creating awareness has to be perceived by a person	The attention of the person has to be caught in some way by the bar charts.
2 Understanding	The person has to understand what the content of the perceived method is	It is about the differences in priorities of issues (and, additionally, options for performance awareness)
3 Interpretation	The person has to interpret the content in the context of the situation	Understanding what the differences in priorities mean for the negotiation
4 Behavior	The person has to change his/her behavior based on the interpretation	Engaging in integrative negotiation

INDIVIDUAL CHARACTERISTICS IN NEGOTIATIONS

Partners enter a negotiation with their individual personality and other individual characteristics which might not only shape their own outcome but might also do so for the outcome of the partner. Only recently the focus of negotiation studies shifted to the interindividual influences using the actor-partner interdependence model (APIM; Kenny, Kashy, & Cook, 2006) as the appropriate statistical method for the analysis (Turel, 2010).

Studies concerning personality – as measured with the "big five" personality factors – and individual negotiation outcomes have shown inconsistent results (Barry & Friedman, 1998; Foo et al., 2004; Liu, Friedman, & Chi, 2005; Ma & Jaeger, 2005). The freely available HEXACO personality scales (Ashton & Lee, 2009) are comparable to the "big five" and operationalize the most up to date model of personality structure . They have never before been applied in any negotiation study and in this context, also never analyzed with the actor-partner interdependence model.

It is not only the personality which plays an important role in computer-supported negotiations with a graphical decision aid at its core but also additional characteristics like the social value orientation (Murphy, Ackerman, & Handgraaf, 2011) and the figural intelligence (Liepmann, Beauducel, Brocke, & Amthauer, 2007). The social value orientation is a set of "motivations that underlie interdependent decision behavior" (Murphy et al., 2011, p. 711) and is a measure of the magnitude of the concern people have for others (Murphy et al., 2011). It already has a big influence on the joint outcome in negotiations (De Dreu, Weingart, & Kwon, 2000). When using a graphical decision aid in a negotiation support system, there is a strong connection to one's general ability to understand and process graphically represented information. The interindividual effects of the social value orientation and the figural intelligence on the individual outcome have not been tested until now.

Actor-Partner Interdependence Model

The data of the second study – comparing priority with performance awareness – were analyzed on the individual level with the actor-partner interdependence model.

The negotiation dyads are not independent of each other and, therefore, the effects of different characteristics on the individual outcomes cannot be analyzed without taking the partner into account. The buyer and the seller have both an actor effect – the effect of one of the partner's own characteristic on his or her own individual outcome – and a partner effect – the effect of one of the partner's own characteristic on the individual outcome of the other partner (Figure 5).

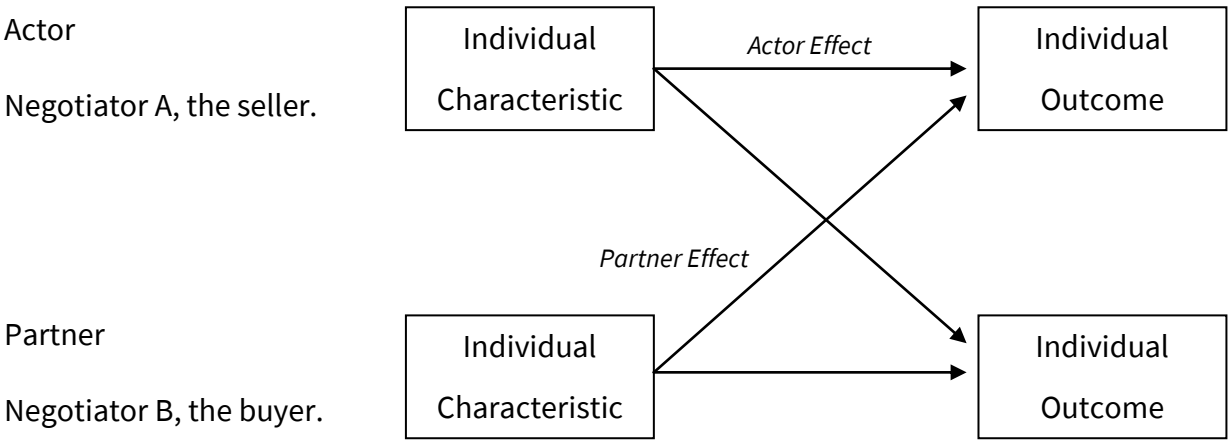

Figure 5. Simplified Schematic of the Actor-Partner Interdependence Model

The main idea behind these analyses is to find out, how the personality traits – measured with the HEXACO – the social value orientation and the figural intelligence affect the negotiators' individual outcomes in negotiation support systems with different amounts of information (awareness) and interactivity.

Because of the heterogeneity of previous findings and the novelty of this endeavor only research questions are stated:

RQ1: *How does personality affect the individual outcomes?*

RQ2: *How does the social value orientation affect the individual outcomes?*

RQ3: *How does figural intelligence affect the individual outcomes?*

OBJECTIVES AND EXPECTED OUTPUT OF THE THESIS

The broad idea, starting this thesis was to implement the concept of the previously developed knowledge and information awareness approach (Engelmann, Kolodziej, et al., 2014; Engelmann, Kozlov, et al., 2014) in a more organizational context, namely negotiations. The objective of the first article in this thesis (Kolodziej, Hesse, et al., 2016) can be seen as a proof of concept: Can priority awareness be tacitly facilitated with bar charts in a computer-supported negotiation? This tacit approach could diminish the fixed-sum-error and incompatibility error – without the need for specific experience, training or

instructions – lead to more integrative negotiations and improve different hard and soft measures of negotiation performance.

The second article (Kolodziej, Sassenberg, et al., 2016) builds upon the findings and shortcomings of the priority awareness approach. While a non-interactive priority awareness approach could diminish the fixed-sum error, the incompatibility error was still strong. Making more use of information and communication technologies capabilities to create performance awareness – a more detailed priority awareness – through the use of interactivity could also diminish the incompatibility error and further improve different measures of negotiation performance. Contrary to such positive effects stand the cognitive load theory, the regret theory and the need for strategic misrepresentation which foreshadow the limits of awareness in negotiations.

The third article (Kolodziej & Sassenberg, 2016) goes deeper into individual characteristics which hugely influence the individual outcome in such computer-supported negotiations with differing amounts of information (awareness) and interactivity. The objective of this study is how personality traits, social value orientation and figural intelligence interindividually affect the negotiators in such a negotiation support system. The actor-partner interdependence model is used to analyze the data from the second article on an individual level.

In total this thesis introduces the priority awareness approach and shows that it leads to better negotiation performance. It also shows the limits of priority awareness in negotiations and explores the underlying individual characteristics, which show a surprising pattern for being beneficial to one or the other negotiator.

RESULTS AND DISCUSSION

The same results and discussions mentioned here can also be found similarly in the three main articles attached to this thesis. Although the author of this thesis is mainly responsible for the creation of the articles their underlying studies and analyses, the articles were published in collaboration with other authors. Hence, the active use of "we" in the following sections to meet the demand to address the coauthors.

For an overview of all hypotheses and research questions addressed in this thesis see Table 3.

Table 3

Overview of all Addressed Hypotheses and Research Questions in This Thesis

Article 1 – Priority Awareness	
H1	Dyads negotiating with available priority awareness agree on a higher joint outcome than dyads negotiating without priority awareness.
H2	Dyads negotiating with available priority awareness achieve a higher pareto efficiency than dyads negotiating without priority awareness.
H3	Dyads negotiating with available priority awareness arrive at a lower impasse rate than dyads negotiating without priority awareness.
RQ1a/b	How does priority awareness affect the objective and subjective fairness of the agreement?
RQ2	How does priority awareness affect the satisfaction with the negotiation?
RQ3	How does priority awareness affect the duration of the negotiation?

Article 2 – Performance Awareness	
H1	Dyads negotiating with available priority awareness differ in the economic outcome measures of the negotiation from dyads negotiating with available performance awareness.
H2	Dyads negotiating with available priority awareness differ in their satisfaction with the negotiation and their partner from dyads negotiating with available performance awareness.
H3	Dyads negotiating with available priority awareness differ in the fairness of the negotiation from dyads negotiating with available performance awareness.
H4	Dyads negotiating with available priority awareness differ in their practiced and perceived deceitfulness during the negotiation from dyads negotiating with available performance awareness.
H5	Dyads negotiating with available priority awareness differ in how they deal with information for future negotiations from dyads negotiating with available performance awareness.
Article 3 – Individual Characteristics	
RQ1	How does personality affect the individual outcomes?
RQ2	How does the social value orientation affect the individual outcomes?
RQ3	How does figural intelligence affect the individual outcomes?

Priority Awareness

Results. For the analyses of all hypotheses, except the one concerning the impasse rate, we followed the advice of Tripp and Sondak (1992) and excluded all dyads which stated an impasse and therefore did not achieve any interpretable outcome. This approach left 60 dyads in the sample (n_{EC} = 28, n_{CC} = 32). Substituting a non-agreement with a zero or mean point score distorts the results because such dyads did not agree on a zero or mean point score but did not agree at all. We used the aggregated data of the negotiation dyads for all analyses because the individuals were not independent of each other (Cress, 2008). Depending on whether the assumptions of different statistical methods such as, for example, a normal distribution of values or the homogeneity of variance were met, we

either calculated a t-Test, a Wilcoxon rank-sum test, a pairwise Wilcoxon rank-sum test with a p-value adjustment by Holm (1979), or a Chi-squared test with their appropriate effect sizes to compare the performance of the conditions.

There were no significant differences on the group level in terms of the control measures age, familiarity with the partner, computer abilities, effortlessness, and frequency of using tables or diagrams. We assessed the level of experience of the negotiators by looking at their individually stated frequency of previous negotiations. The participants were “rather unexperienced” ($M = 2.39$, $SD = 0.86$) in negotiating.

H1 confirmed: The dyads with priority awareness agreed on a higher joint outcome ($M = 9793$, $SD = 1960$) than dyads without priority awareness ($M = 8775$, $SD = 1890$, $t(58) = 2.05$, $p = .045$, $d = .53$). This makes up for a difference in the mean of 12%.

H2 partially confirmed: The dyads with priority awareness also achieved a marginally higher pareto efficiency in their negotiation ($M = .959$, $SD = .13$) than the dyads without priority awareness ($M = .935$, $SD = .12$, $W = 568.5$, $p = .074$, $r = -.23$). This makes up for a difference in the mean of 2.4%.

H3 disconfirmed: The dyads with priority awareness arrived at a marginally higher impasse rate ($n = 5$) than dyads without priority awareness ($n = 1$, $\chi^2(1, N = 66) = 2.93$, $p = .087$, $\varphi = .21$).

Although it seems that dyads with priority awareness achieved an objectively fairer agreement ($M = 36.7\%$, $SD = 34.0\%$) than dyads without priority awareness ($M = 50.9\%$, $SD = 49.7\%$, $W = 361$, $p = .197$) they did not differ significantly (RQ1a). They also did not differ in the subjective fairness of agreements ($M_{EC} = 3.23$, $SD_{EC} = .49$, $M_{CC} = 3.27$, $SD_{CC} = .43$, $W = 440$, $p = .904$) which both conditions stated as “rather fair” (RQ1b).

We also did not find any difference in the satisfaction with the negotiation between dyads with priority awareness ($M = 3.05$, $SD = .33$) and dyads without priority awareness ($M = 3.07$, $SD = .41$, $t(58) = -0.22$, $p = .828$). Dyads of both conditions were “rather satisfied” with their negotiations (RQ2).

With regard to RQ3, we found no difference in the duration of the negotiation between dyads with priority awareness (*M* = 12:03 minutes, *SD* = 07:19 minutes) and dyads without priority awareness (*M* = 11:31 minutes, *SD* = 06:07 minutes, *W* = 548, *p* = .970).

The transcription of the audio recordings of the negotiations resulted in 7911 lines of utterances which were independently coded by two raters on three variables, with either a 0 or a 1: (1) Reference to the bar chart, for example, “We can take financing and warranty; it seems as if we both have a large and a small bar.” (2) Reference to priorities, for example, “It's more important for me that the CO_2 emission is alright. The color is not important to me at all.” (3) Reference to point scores, for example, “Yes, how many points do you get for multimedia equipment and car computer?”

Cohen's Kappa for two raters showed moderate to substantial agreement (Landis & Koch, 1977) between the independent raters with $\kappa_{RefBarChart}$ = .56, $\kappa_{RefPriorities}$ = .64 and $\kappa_{RefPreferences}$ = .61. In the following step, the raters agreed on one correct rating for each utterance by working through the whole transcription together. This unified rating was used for the next calculations.

Dyads with priority awareness referred to the bar chart more often (*SUM* = 154) than dyads without priority awareness (*SUM* = 32, *W* = 7581658, *p* < .001, *r* = -.10). They also referred to priorities more often (*SUM* = 198) than dyads without priority awareness (*SUM* = 141, *W* = 7724479, *p* = .023, *r* = -.03). Both conditions did not differ in their reference to point scores (SUM_{EC} = 600, SUM_{CC} = 538, *W* = 7789097, *p* = .789).

Discussion. The knowledge about the priorities of a negotiation partner could be assumed to have a high impact on the economic outcome of a negotiation because it creates the possibility of an integrative agreement in which the negotiators give in on less important issues and, in exchange, take on more important ones. Until now, no study has systematically tested the effect of making the negotiators only aware of the differences between their priorities on different measures of negotiation outcome. Our goal was to create this priority awareness with an intervention so trivial that it could be implemented with minimal effort. We therefore used ordinary bar charts as known from business

reports or school books. None of the negotiators was instructed on how or why to use the bar charts and none of them was kept from freely exchanging any information whatsoever. The negotiation dyads could perceive the bar charts as an awareness tool, they could understand its benefit and they could use it for making more trade-offs to achieve a better negotiation performance.

The results of 66 computer-supported negotiations between the roles of a car buyer and seller have shown that negotiation dyads, which were made aware of the priorities of their negotiation partner, negotiated an averaged 12% higher joint outcome than dyads which were not made aware of the priorities of their negotiation partner. Dyads with priority awareness tended to arrive at averaged 2.4% more pareto efficient agreements, leaving less profit on the table. Surprisingly, dyads with priority awareness might have been slightly more likely to abort the negotiation than dyads without. There were no differences between dyads negotiating with or without priority awareness on the measures stated in the open research questions. Both conditions did not differ in the duration of the negotiation, the objective or subjective fairness of the agreement, or their satisfaction with the negotiation.

It is possible to make negotiators aware of each other's priorities in a tacit and unobtrusive way. The results of the study speak for the effectiveness of the priority awareness approach. It would be possible to integrate this approach – creating priority awareness through bar charts – in existing negotiation support systems, at least in an optional way. Furthermore, a specialized negotiation support system is not needed for real life negotiations in order to make use of priority awareness. Agreeing on using this approach and a spreadsheet program are already sufficient to improve the negotiation performance. It is even conceivable that both parties agree to draw bar charts representing their priorities of issues on a single sheet of paper. The usage of a single sheet of paper needs further research as it differs in a great way from computer-supported negotiations.

Further, this approach is not about negotiations over the distribution of a product alone but about decision making in general. The use of a negotiation support system with an optional priority awareness function would be advisable and every improvement of the

agreement would benefit all parties. An example would be different departments of one organization, which clearly have the common goal of success for the organization although they have different priorities. Being aware of these differences and using them for integrative decision making would benefit the organization as a whole and, in return, all of the departments. The feasibility of this idea was shortly presented by Thiemann and Engelmann (2015).

Regarding bar charts, it becomes obvious how omnipresent they are in everyday life. They are quick to make and seem easy to understand. But the ability to correctly read and interpret even ordinary bar charts is not necessarily intuitive and has to be learned by some people. This study gave us a hint that some people had at least initially difficulty understanding the bar chart and therefore they could have lacked the advantage of those with a higher aptitude for this type of visual literacy. Especially in business settings, it is crucial to be able to read bar charts, understand them, and to react to their information in order to make adequate decisions. Organizations also use bar charts to portray their performance in a better light (Beattie & Jones, 1992). Thus a critical examination of bar charts would not only be wise for the sake of fostering priority awareness to improve negotiations but also in many other business related situations. Such visual literacy is taken for granted for the most people because we are exposed to bar charts ever since entering school. There is no special emphasis in schools on teaching visualizations or graphical decision aids, but as we strongly rely on them to simplify and aggregate information for us to make decisions, it would be advisable to at least in some way address the task of reading, understand, and interpreting graphical decision aids.

Somewhat limiting in this study was, that the participants were rather unexperienced in terms of negotiations. The effectiveness could be even higher in real life negotiations. People negotiating for a living could have taken more out of the awareness of the priorities of the others. They have the experience needed to understand this information better and to make better use of the integrative potential of the negotiation. On the other hand, it has been shown that even unexperienced negotiators without training could make beneficial use of priority information when made aware about them.

We would like to point out that the influence of priority awareness on the impasse rate has never been measured in this way before and that it is only meaningfully interpretable if enough impasses occur naturally. If it would not have been counterhypothetical, this result could have been ignored because the total number of impasses was so low that it can only be interpreted in a descriptive way. Nevertheless, a possible explanation could be that fostering awareness of the priorities of the other party works well in making the integrative potential of the negotiation visible, but the possible unwillingness of one negotiator to make concessions – even though his or her priorities are available to the other – would lead the other negotiator to abort the negotiation. Future studies will show whether this is a recurring phenomenon or just a coincidence in the sample of participants.

This experiment has shown that the bar charts in our study had their own share of drawbacks in their simplicity. An informal questioning of the participants after the experiment showed that many expected an interactive instead of a non-interactive bar chart. They were surprised that the bars did not change in size in correspondence to the marked options in the negotiation because they were accustomed to more interactivity in a computer-supported environment. A non-interactive bar chart has now been proven to successfully foster priority awareness, but it may not deliver enough information in a computer-supported environment for the negotiators and also has its limitations as it does nothing to resolve the incompatibility error (Thompson, 1991). Forty-five percent of all dyads did agree at least in one of two compatible issues on an option that was suboptimal for both negotiators although both preferred the identical option. They agreed on a joint loss. In our next study, we use interactive bar charts to foster priority awareness and compare them to the non-interactive bar charts. This interactivity could create not only a better awareness about priorities but also another quality of awareness. The negotiators would not only be made aware of the different priorities of issues but also of the different priorities of options, as the bars would change in size according to the marked options in the negotiation. This could result not only in an even better negotiation performance but, while creating awareness for differences between issues, also create

awareness for the similarities between issues and help to resolve the incompatibility error.

For the present study and the next study with interactive bar charts, we assume a state in which negotiation parties truthfully and openly share all the information about their priorities. Negotiations here take place in a manner of a full, open, truthful exchange (FOTE; Raiffa et al., 2002) which is also assumed in other studies (e.g. Herath, Bremser, & Birnberg, 2010). This can be considered a limitation of this study because although negotiations take place in such a manner, the case of a partial open, truthful exchange (POTE), in which not all information is shared, is prevalent in real life negotiations. After we have established that priority awareness improves negotiation outcomes at the level of the issues in this study, and we have evaluated whether it works better on the additional level of options in a second study, we will address the partial open, truthful exchange of priorities in a potential third study on priority awareness not part of this thesis. This will further validate the priority awareness approach and make way for its implementation in existing negotiation support systems and for its broad usage in a computer-supported environment to enhance integrative decision making in a multitude of natural settings.

Conclusion. A trivial bar chart including the priorities of the other negotiator is enough to improve the negotiation performance, without negative consequences on satisfaction, fairness and duration. This kind of awareness is enough for the most, there are no further instructions needed. Such a simple and inexpensive way to improve – not only – computer-supported negotiations could easily be integrated as an optional feature in existing professional negotiation support systems and benefit its users.

Performance Awareness

Results. For the analyses we used a Wilcoxon rank-sum test or, where the normality assumption was not violated, a t-Test. There were no meaningful differences between the conditions in the control measures age, familiarity with the partner, computer abilities, effortlessness, and frequency of using tables or diagrams (all Ws > 2077 with N = 132, all ps > .165). Both conditions can be seen as identical and all differences in the measures of negotiation performance can be ascribed to the condition. All analyses were conducted on the aggregated data on the level of dyads because the individuals were not independent of each other (Cress, 2008). There were no impasses and all dyads achieved a positive joint outcome.

Table 4 holds an overview of the correlations between the used measures of negotiation performance. All measures forming one hypothesis are significantly correlated with each other.

Table 4

Overall Correlations between the Used Measures of Negotiation Performance

	Joint outcome	**Pareto efficiency**	**Satisfaction**	**Likeability**	**Objective fairness**	**Subjective fairness**	**Personal deceitfulness**	**Perceived deceitfulness**	**Information disclosure**	**Information memory**
Joint outcome		0.996***	0.060	0.019	-0.175	0.018	0.085	0.032	0.319**	-0.009
Pareto efficiency	0.996***		0.069	0.030	-0.195	0.031	0.074	0.042	0.324**	-0.029
Satisfaction	0.060	0.069		0.493***	-0.212	0.660***	-0.480***	-0.473***	-0.137	-0.047
Likeability	0.019	0.030	0.493***		-0.199	0.566***	-0.547***	-0.567***	-0.330**	-0.112
Objective fairness	-0.175	-0.195	-0.212	-0.199		-0.319**	0.265*	0.255*	0.027	0.350**
Subjective fairness	0.018	0.031	0.660***	0.566***	-0.319**		-0.604***	-0.602***	-0.282*	-0.211
Personal deceitfulness	0.085	0.074	-0.480***	-0.547***	0.265*	-0.604***		0.701***	0.482***	0.216
Perceived deceitfulness	0.032	0.042	-0.473***	-0.567***	0.255*	-0.602***	0.701***		0.471***	0.076
Information disclosure	0.319**	0.324**	-0.137	-0.330**	0.027	-0.282*	0.482***	0.471***		0.298*
Information memory	-0.009	-0.029	-0.047	-0.112	0.350**	-0.211	0.216	0.076	0.298*	

Spearman's correlation with pairwise-deletion. *$p < .05$, **$p < .01$, ***$p < .001$.

H1 disconfirmed: Both conditions did not differ in the agreed joint outcome (M_{PriA} = 10055, SD_{PriA} = 2428, M_{PerA} = 9055, SD_{PerA} = 2796, p = .262) and the achieved pareto efficiency (M_{PriA} = 0.96, SD_{PriA} = 0.10, M_{PerA} = 0.89, SD_{PerA} = 0.26, p = .228).

H2 confirmed: The negotiation dyads with priority awareness (M = 3.23, SD = 0.40) were more satisfied with the negotiation than the dyads with performance awareness (M = 2.99, SD = 0.44, W = 690, p = .031, r = -.28) and they also found their negotiation partner more likeable (M_{PriA} = 3.49, SD_{PriA} = 0.40, M_{PerA} = 3.18, SD_{PerA} = 0.42, W = 749, p = .003, r = -.37)

H3 confirmed: The negotiation dyads with priority awareness (M = 3.43, SD = 0.41) found their agreement subjectively fairer than the dyads with performance awareness (M = 3.20, SD = 0.40, W = 702.5, p = .020, r = -.41). Objectively, there was no difference in the fairness of the agreement between the conditions (M_{PriA} = 16.5%, SD_{PriA} = 22.0%, M_{PerA} = 22.6%, SD_{PerA} = 30.4%, W = 453, p = .237)

H4 confirmed: The negotiation dyads with priority awareness (M = 1.51, SD = 0.41) not only said that they were less deceitful in the negotiation than the dyads with performance awareness (M = 1.88, SD = 0.43, W = 283, p = .001, r = -.41), and they also perceived their negotiation partner as less deceitful (M_{PriA} = 1.59, SD_{PriA} = 0.40, M_{ProA} = 1.80, SD_{ProA} = 0.36, $t(63)$ = -2.15, p = .036, d = .53).

H5 confirmed: The negotiation dyads with priority awareness (M = 2.27, SD = 0.63) were more willing to also present their full payoff schedule to their partner in future negotiations than the dyads with performance awareness (M = 2.58, SD = 0.55, $t(63)$ = -2.13, p = .037, d = .53). In replicating the priorities from the other party after the negotiation, the negotiation dyads with priority awareness (M = 25.76, SD = 5.38) remembered fewer correct priorities of the other party than the dyads with performance awareness (M = 20.18, SD = 7.49, $t(64)$ = 3.48 , $p < .001$, d = .86).

Discussion. A successful negotiation strongly relies on the negotiators' awareness of each other's priorities. Being aware of which issues could be traded off in a beneficial way leads to an integrative negotiation. We compared two different kinds of awareness and their influence on different measures of negotiation performance in an experimental

negotiation support system: (1) priority awareness, tacitly facilitated with non-interactive bar charts and (2) performance awareness, tacitly facilitated with interactive bar charts.

Through its interactivity, the performance awareness approach could have possibly facilitated the steps needed to create awareness (see Table 2) and thus diminish the fixed-sum-error. Additionally, it could have possibly created another quality of priority awareness on the level of options as well as issues, which could have reduced the incompatibility error. Making a more extensive use of information and communications technologies, interactive possibilities did not, however, improve the negotiation performance; on the contrary, it even had detrimental effects: There was no difference in the joint outcome or in the pareto efficiency – being indicators for the fixed-sum-error – and ultimately no difference in the commitment of the incompatibility error between dyads negotiating with priority awareness or performance awareness. Dyads negotiating with performance awareness were less satisfied with their negotiation, found their partner less likable, found their agreement less fair – although there was no objective difference in fairness – were more deceitful in the negotiation, and also thought their partner was more deceitful. There were two results in which dyads negotiating with performance awareness had a higher score than those negotiating with priority awareness. On the one hand, they could remember the priorities of their partner better and, on the other hand, they were less willing to disclose even more information in form of their payoff schedule.

Although the performance awareness approach was assumed to have a great potential for being superior to the priority awareness approach, it was mostly inferior to it. An explanation of why there was no difference in the joint outcome and the pareto efficiency between the conditions lies in the higher complexity of the interactive bar charts and their greater need for cognitive resources (Chandler & Sweller, 1991). Further, although performance awareness created awareness of the priorities of options inside issues, making the options discoverable – which both negotiators unanimously preferred – and thus potentially circumventing the incompatibility error, we believe that the negotiators were too busy handling the higher complexity that accompanied the introduced interactivity to have also noticed these kinds of options. The interactivity may have led to too much awareness and too much information to process at once. This is also

in line with Schmutz et al. (2009) where higher complexity led likewise to less satisfaction with a computer system.

The regret theory (Bell, 1982; Loomes & Sugden, 1982) holds an answer to why performance awareness had these adverse effects on satisfaction with the negotiation, likeability of the partner, the subjective fairness of the agreement, as well as the personal and the perceived deceptiveness. These five concepts were significantly correlated with each other, indicating that these are interrelated concepts which might have been influenced at once. Performance awareness not only showed the current performance in the negotiation, but also made the transition from a previous state more salient: The negotiators were made aware of what they have lost in the transition of one offer to another and what the other negotiator had received in return, which may not have been a fair trade. Also, the goal of the negotiation was to maximize the individual points – to get the bars to an optimal size. Being made aware of a deviation from this goal could have also led to frustration.

As for the higher deceptiveness and the perceived deceptiveness of the partner in the performance awareness condition, there seems to be a need for strategic misrepresentation (Steinel & De Dreu, 2004), which becomes more visible, the less information there is that the negotiators can hide. In a scenario in which each negotiator is made aware of the other's priorities of issues and options, complete rational and fair negotiators would achieve a perfect integrative agreement with the highest possible joint outcome and perfect pareto efficiency. But humans are not completely rational and fair (f. e. Henrich et al., 2001). The highest individual outcome is only possible at the cost of the negotiation partner's individual outcome. In a scenario in which more detailed information about one's priorities is available, the only possible way to gain a higher individual outcome is to be deceptive. But because the priority information is available, this deception is easier to see through.

The dyads with priority awareness were more willing to even share their individual payoff schedule. Dyads with performance awareness already had more awareness and they were less convinced of sharing even more information. The correlations with the joint outcome and pareto efficiency indicate that a higher willingness to share even more

information was connected to a better economical negotiation outcome. It seems as if awareness of negotiation relevant information has its benefits and people assume that more would be better, but when they have more awareness of negotiation-relevant information, they change their mind. This again is an indicator of the need for strategic misrepresentation of information because people who have less opportunity to deceive are also less willing to share even more information.

The individual payoff schedule is the basis of every complex negotiation. It attaches measureable values to options and creates priorities for issues. Otherwise, negotiators would have to rely on fast assumptions of which issue or option is more or less important to them. Giving away the individual payoff schedule is a full disclosure of the key information in a negotiation. Our results show that negotiators would prefer a partial, open, truthful exchange over a full, open, truthful exchange (Raiffa et al., 2002).

After the negotiation, the dyads with performance awareness knew more about the priorities of their negotiation partner than the dyads with priority awareness. Remembering the priorities of the partner after the negotiation is useful for recurring negotiations between the same parties as this would save time in coming to terms with the others' priorities. Other studies on awareness centered on learning and problem solving. In these studies, the extent of the knowledge that one group member gained about the others was assessed (e. g. Engelmann, Dehler, Bodemer, & Buder, 2009). In such a context, added interactivity and more detailed awareness would be more useful since it has been clearly shown to lead to more engagement with the information of the other and better retention.

A shortcoming of the present study is the mentioned full, open, truthful, exchange of information that we granted the negotiators. We did so to be able to compare the effectiveness of the two different awareness conditions, which could not have been properly done without giving away all priority information about issues (and options). Through a full, open, truthful exchange in a negotiation, the negotiators may "gain clarity, simplicity and crispness of definition" (Raiffa et al., 2002, p. 87, p. 87) about their negotiation which also is the case in reality (Herath et al., 2010; Raiffa et al., 2002). A partial, open, truthful exchange is also the case in reality: Not all information is exchanged

open and truthfully. Sometimes a full, open, truthful exchange is not possible with a partner who cannot be trusted and sometimes negotiations start out as partially open and truthful but then change to fully open and truthful, understanding its benefits (Raiffa et al., 2002).

Interactive visualizations are broadly used in economical decision making (Dilla, Janvrin, & Raschke, 2010). Their goal is to interactively visualize different key performance indicators to help decision-makers or negotiators to come to a beneficial decision and in the context of a negotiation, a beneficial agreement. This study leads to the question how many interactive computer-supported environments could work as well as non-interactive ones which are implemented in a faster, cheaper, and simpler way. It is not a question of adding more interactive features but removing some. Removing features, reducing the amount of information, and limiting the amount of possible interaction could lead to the same or even better outcomes. Future studies will have to focus on simpler ways of creating a limited amount of awareness and also on a partial, open, truthful exchange of information, answering the question: How much voluntarily given awareness about one's own information is enough to improve negotiation performance?

Conclusion. There seems to be the phenomenon of too much awareness. Performance awareness makes the current state of the negotiation salient to the negotiators and can clearly help facilitate decision making processes in a computer-supported environment. It unfortunately also leads to simply too much information to handle at once efficiently, to feelings of regret, and prevents the use of strategic misrepresentation. These effects have a negative influence on satisfaction, fairness, and honesty. Such an awareness approach comes with its share of disadvantages that does not justify the additional amount of time and resources needed to create and maintain it. Non-interactive awareness approaches are easier and cheaper to create and maintain and optimally do not take up much mental effort in using them, do not leave the negotiators with feelings of regret, and should still leave the negotiators some room for strategic misrepresentation of information.

Individual Characteristics

Results. Table 4 holds an overview of all significant results of the actor-partner interdependence model analyses. There were no condition specific results found.

Table 4

Overview of Results of the Actor-Partner Interdependence Model Analyses

Measure	Actor Effect on Individual Outcome	Partner Effect on Individual Outcome		
	β	β	b	r
HEXACO Emotionality	.036	**-.173**	**-337**	**-.173**
Dependence	-.039	**-.188**	**-368**	**-.184**
Sentimentality	-.087	**-.225**	**-438**	**-.221**
Anxiety	.112	-.044		
Fearfulness	.154	-.074		
HEXACO Honesty Humility	-.079	.070		
Sincerity	-.159	.101		
Fairness	-.073	-.056		
Greed Avoidance	-.041	.070		
Modesty	.039	.121		
HEXACO Extraversion	-.096	-.024		
Social Self-Esteem	-.160	.068		
Social Boldness	-.092	-.080		
Sociability	-.018	-.053		
Liveliness	-.030	-.047		

HEXACO Agreeableness	-.076	-.044		
Forgiveness	.030	.030		
Gentleness	-.082	-.088		
Flexibility	-.104	-.016		
Patience	-.113	-.068		
HEXACO Conscientiousness	.073	-.060		
Organization	-.038	-.068		
Diligence	.038	.007		
Perfectionism	.119	-.054		
Prudence	.084	-.097		
HEXACO Openness to Experience	-.085	.122		
Aesthetic Appreciation	-.051	.059		
Inquisitiveness	-.097	.121		
Creativity	-.043	.091		
Unconventionality	-.029	.076		
Social Value Orientation	.020	**.206**	**401**	**.195**
Figural Intelligence	.004	**.199**	**389**	**.191**

Besides Social Value Orientation with $N = 130$ individuals in $N = 65$ dyads (due to technical errors) all $N = 132$ individuals in $N = 66$ dyads. Effects marked bold are significant with $p < .05$.

The individual characteristic of the HEXACO scale emotionality had a partner effect on the individual outcome. A negotiator's own emotionality had no influence on his or her own individual outcome but the more emotional the opposing partner was, the lower the negotiator's own individual outcome turned out to be. Two subscales of emotionality, namely, dependence and sentimentality had similar effects.

The individual characteristic of the subscale dependence also had a partner effect on the individual outcome. A negotiator's own need for emotional support from others had no influence on his or her own individual outcome but the more the opposing partner needed emotional support, the lower the negotiator's own individual outcome became.

The individual characteristic of the subscale sentimentality had a partner effect on the individual outcome too. A negotiator's own strength of feeling an emotional bond had no influence on his or her own individual outcome but the higher the strength of feeling an emotional bond of the opposing partner was, the lower the negotiator's own individual outcome turned out to be.

The individual characteristic of the social value orientation had a partner effect on the individual outcome. A negotiator's own social orientation had no influence on his or her own individual outcome but the more social the orientation of the opposing partner was, the higher the negotiator's own individual outcome was.

The individual characteristic of the figural intelligence had a partner effect on the individual outcome. A negotiator's own figural intelligence had no influence on his or her own individual outcome but the higher the figural intelligence of the opposing partner was, the higher the negotiator's own individual outcome was.

Discussion. In this experimental study, we sought to find answers on how the HEXACO personality scales and relevant measures such as figural intelligence and social value orientation affected the individual outcomes in a computer-supported negotiation. To accomplish this, we compared two conditions with negotiation support system, differing in their amount of information and interactive capabilities, which ultimately did not differ in their results. Interestingly, a negotiator's own personality traits had no influence on his or her own individual outcome. A negotiator's own individual outcome lies mostly in the hands of the opposing partner. Table 5 holds an overview of the partner's characteristics which may improve a negotiator's own individual outcome in a computer-supported negotiation.

Table 5

Partner's Characteristics that Improve a Negotiator's own Individual Outcome Within a Negotiation Support System

Measure	Partner's characteristic
HEXACO Emotionality	Lower emotionality
Dependence	Lower need for emotional support
Sentimentality	Lower strength of feeling and emotional bond
Social Value Orientation	Higher prosocial attitude
Figural Intelligence	Higher figural intelligence

Higher emotionality, a higher need for emotional support, and a higher feeling of an emotional bond are personality traits of one negotiation partner which could elicit caring behavior in the other negotiator or a stronger emotional bond, resulting in more concessions from the other negotiator. The only other study using the direct individual outcome in connection with personality traits, as we did, showed that a higher emotionality – or neuroticism – improved the individual outcome (Foo et al., 2004). However, it seems to be true that the high emotionality of one negotiation partner does not improve his or her own individual outcome, but it instead worsens the individual outcome of the less emotional negotiation partner. Further studies are needed to fully understand the individual influence of emotionality on the individual outcomes as a higher score in this personality trait is common in the population and has a high economic cost for society (Cuijpers et al., 2010).

The higher social value orientation of one negotiation partner, improving only the individual outcome of the other, fell in line with previous research: Prosocial individuals were less demanding but simultaneously more giving and considerate (Dreu & Lange, 1995). This would explain the higher individual outcome of their negotiation partner. It is still interesting to see that social orientation of a negotiator had no influence on his or her own individual outcome.

The higher figural intelligence of the partner played an important role in the negotiation with a negotiation support system using a graphical decision aid: The understanding of the graphical decision aid is crucial for beneficial trade-offs, and lacking the general ability to understand figural representations might hinder this process. We believe that the negotiator with a better understanding of the graphical decision aid offered more profitable concessions to the other negotiator, but in return received less profitable concessions back due to the other's lower general ability to understand the figures in form of bar charts.

One shortcoming of this experimental study is that these findings for the HEXACO scales and the findings for the Big Five are not fully comparable: (1) Although the HEXACO is very similar to the Big Five, it is not identical. (2) Previous studies did not use the actor-partner interdependence model but lesser methods to test the influence on individual outcomes. (3) Previous studies did not use the direct individual outcome measured in points but the individual deviation from a preset individual target.

More studies researching the HEXACO scales in a computer-supported negotiation, using the actor-partner-interdependence model for analysis of the direct individual outcome are needed to create a more complete knowledge base on the influence of personality traits on individual outcomes in negotiations. Also, further research is needed to fully assess the reasons, why the negotiator's own individual outcome lies mostly in the hand of the partner and stays uninfluenced by one's own characteristics.

Conclusion. Negotiators seem to compensate the deficiencies of their partner with their own share of the gain in a negotiation. Furthermore, the individual outcome of one partner seems highly dependent upon the personality and prosocial behavior of the opposing partner. The worst negotiation partner using a negotiation support system with graphical decision aids would be the one who is emotionally unstable and competitive and who has problems interpreting figures. This negotiation partner will not feel the effects of his or her shortcomings, but the one negotiating with this partner will suffer a lower individual outcome. Asking for an experienced negotiator is therefore advisable, especially when using a computer-supported environment.

General Discussion

The articles in this thesis build upon each other and paint a comprehensive picture of improving different measures of negotiation performance through the awareness of priorities. It could not only be shown, that the tacit priority awareness approach works but also that there are limits to this kind of awareness in computer-supported negotiations. On top, not all negotiators profit equally in such negotiations. Their different characteristics influence their individual outcomes in which being the less talented and experienced negotiator actually translated into a better individual outcome.

The findings in the first article came out quite as hypothesized. Tacitly fostering priority awareness with bar charts is possible in computer-supported negotiations and it leads to an improved joint outcome and a marginally better pareto efficiency. It did not have an influence on objective and subjective fairness, the satisfaction with the negotiations and the duration of the negotiation. The impasse rate was higher in the priority awareness condition but as discussed, this seems to be a coincidence in the sample of participants as the second study for the second article did not have a single impasse in the same number of negotiations.

The performance awareness approach in the second article, which delivered more detailed priority information through the use of interactivity, was not economically superior in the means of joint outcome and pareto efficiency to the established priority

awareness approach. It was even detrimental to fairness, satisfaction and deception. The three different theories discussed hold an answer to why more awareness had these effects.

The findings in the third article went into a slightly different direction as assumed. Analyzing the data from the second study on the individual level, all reported results did not show any awareness condition specific effects. In the general use of a negotiation support system the characteristics of the negotiation partner are of high importance; more emotional and prosocial partners with lower figural intelligence will achieve a better individual outcome.

The logical next studies would focus on two areas, continuing the raised questions in the three main articles of this thesis. The first one would be the partial, open, truthful exchange of information, which was already discussed in the first two articles. Fully, open and truthfully exchanging priority information happens in real life negotiations but it is more often the case that not everything is shared and not everything is shared truthfully. How much (truthful) priority information has to be shared for this approach to work? What if only one negotiator (truthfully) shares priority information? Why do or do not negotiators share (truthful) priority information? How can the sharing of (truthful) priority information be improved? The robustness of the priority awareness approach under real life negotiation conditions still has to be proven although the pioneering articles in this thesis are already very promising. Integrating this economically beneficial approach as an optional feature in current real life negotiation support systems is already possible, but answering these open questions would be the next step in fully implementing such approach, transferring the theoretical groundwork into real practical use.

The second area of future studies would further explore the individual characteristics in computer-supported negotiations. Minor results not reported in the article three showed effects which differed between the priority and performance awareness approach. There were interaction effects between the self-stated computer skills, effortlessness of using tables/charts, frequency of using tables/charts and the condition. The better the computer skills, the less effort with tables/charts and the more frequent use of tables/charts the opposing partner had, the higher was the negotiator’s

own individual outcome, but only in the performance awareness condition. These measures were assessed through single questions and were therefore not valid enough to justify a mentioning in the article three. There are reasons to believe that the complexity of a negotiation support system and the experience in using such systems or individual differences in the underlying mechanisms like effortlessness and frequency of using tables/charts as well as the general computer skills, are also responsible for the individual outcomes of both negotiators. Combined with area one for future studies, the question about the interindividual effects of specific characteristics which influence the individual outcomes could be further explored.

All the present and future studies and analyses get us closer to not only understanding how to tacitly foster awareness in negotiations to improve negotiation performance – still without the need for experience, training or instructions – but also which underlying psychological effects and cognitive errors, as well as individual characteristics are at work behind this awareness approach.

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APPENDIX A – ACCEPTED PAPERS

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Full length article

Improving negotiations with bar charts: The advantages of priority awareness

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Negotiation performance

ABSTRACT

Negotiations seldom lead to optimal results for the negotiators. The missing knowledge about the priorities of the negotiating parties is one known reason for this. This experimental study examines the effects of priority awareness on different measures of negotiation outcomes. Priority awareness is the awareness of one negotiator about the priorities of the other negotiator. One hundred thirty-two participants were randomly assigned to negotiation pairs in an experimental condition with priority awareness – created implicitly through the usage of an ordinary bar chart – or a control condition without priority awareness. They took over the roles of a car seller or buyer and negotiated within an experimental negotiation support system. They were neither explicitly instructed to use the bar chart in the negotiation or about its benefits, nor were they restricted in sharing any kind of information. The experimental condition showed not only a significantly higher negotiation performance in the form of joint outcome and pareto efficiency than the control condition, but also a higher impasse rate. Creating awareness about each other's priorities in a negotiation has a positive effect on the negotiation performance without noticeable negative effects on satisfaction with, or fairness and duration of, the negotiation.

1. Negotiations and priorities

Differences in priorities play a major role in successful negotiations, whether we are aware of them or not. Whenever there is a conflict based on different interests or different beliefs on what is more important, negotiations may resolve it. Negotiations are not only of concern for salespersons and professional life but also for one's personal life and everyday human interaction – from trade agreements between organizations to workers trying to agree on how to proceed with a construction or students trying to agree on the best approach to solve a task. Both parties have their preferences, both parties have their priorities, but most often, they cannot have their own way without the consent of the other. They have to negotiate because one party does not just give in to the other's wishes and there is no chance to achieve at least a partial win without giving in on some issues. If both parties give in on some issues and if they concede, it would be best for them if these issues were of lower importance to them, so they will then lose less by giving in. Giving in on issues that are less important and instead receiving concessions on issues that are more important is known as *integrative agreement* or *integrative negotiation* (Barry & Friedman, 1998; De Dreu, Beersma, Steinel, & van Kleef, 2007). For such mutually beneficial *trade-offs* to take place, the negotiators must somehow be aware of their different priorities. However, they rarely are aware of their different priorities and how to integrate them into an optimal solution (Hyder, Prietula, & Weingart, 2000; Thompson & Hastie, 1990). In many cases they agree on an equal split on each topic that is negotiated, meeting in the middle for every negotiated issue. This seems fair but leads to a lower common negotiation performance in the sense of *joint outcome* –the sum of the *individual outcomes* of both negotiators represented by point scores given to their agreement – than the trade-off of less important issues against more important ones (Van der Schalk, Beersma, VanKleef, & De Dreu, 2009). The lack of integrative negotiation also leads to less *pareto efficient* agreements, in other words, to agreements in which at least one party could have achieved a better individual outcome without the other party doing worse (Hyder et al., 2000).

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Two reasons why negotiations often lead to worse outcomes are the *fixed-sum error* or *fixed-pie error* and its subordinate, the *incompatibility error* (Thompson & Hastie, 1990). The fixed sum error is the tendency of a negotiator to assume the same priorities of issues for the other negotiator, assuming similarities where there are none. The incompatibility error is the belief of one negotiator that his or her priorities of preferences differ from those of the other negotiator, assuming differences where there are none. Due to the lack of underlying knowledge about the priorities of the other party, negotiators agree on a lower joint outcome (Thompson & Hastie, 1990) and sometimes even arrive at *lose–lose agreements* in which both negotiation parties agree on an unnecessary common loss (Thompson & Hrebec, 1996). Not even experienced negotiators are safe from these fallacies (Thompson, 1990).

When the negotiators do know about each other's priorities in some way, either by freely giving information about priorities (Schei, Rognes, & Mykland, 2006), simply asking the other negotiation party (Hyder et al., 2000; Schei et al., 2006; Thompson & Hastie, 1990) or being guided by a computer program to estimate the others priorities (Foroughi, Perkins, & Jelassi, 1995), they agree on a higher joint outcome. The exchange of priority information in computer-supported negotiations is a "major prerequisite for reaching integrative negotiation outcomes" as discussed by Gettinger and Koeszegi (2012, p. 26), emphasizing the need for further research.

As seen in these studies, the exchange of priorities depends on the negotiators personal experiences with previous negotiations, on their knowledge about the benefits of priorities, and coming up with the idea of giving or asking for information about priorities. Otherwise the exchange of priorities depends on a prestructured computer program explicitly instructing the negotiators to think about the others priorities.

Our approach is different: We want to make negotiators only aware of each other's priorities in a tacit and unobtrusive way. A way that does not explicitly prompt to do something in a specific manner or that does not stand as an obstacle between the negotiators. Regular bar charts as seen in business reports, TV commercials, and so on, are one possible way. We do not depend on the negotiators previous experience with negotiations and their knowledge about the benefits of priorities for the negotiation outcomes, and we do not explicitly instruct them to think about this. Our focus lies clearly on the human aspect, tacitly fostering awareness of differences in priorities between negotiators in order to achieve a better negotiation performance for both. It is not about algorithms or software agents that negotiate in the absence of human interaction by predefined rules. We want to enhance real human negotiations in which two parties attempt to reach an agreement collaboratively with the support of computers.

In the following two sections, we will explain what we mean by *priority awareness* and how the experiment was set up. Also we will explain what exactly the different measures of negotiation performance are before we state our hypotheses and research questions.

2. Priority awareness

Being aware of the priorities of the other negotiator is what we call priority awareness. In fact, the term "priority awareness" has already been coined by De Jong, Tuyls, Verbeeck, and Roos (2008) as a means to take human fairness into account in modelling software agents for a multi-agent system. De Jong et al. (2008) have shown that adding priority awareness to a software agent gave a much better prediction of human behavior, as humans sometimes take different priorities into account and make trade-offs based on them. Our understanding of priority awareness is the same but from a human perspective.

The adaptation of an awareness approach to negotiations seems promising. Previous studies that made spatially separated individuals in computer-supported work groups aware of each other's different knowledge enhanced the effectiveness and efficiency of their solution to a complex problem (Engelmann & Hesse, 2010; Engelmann, Tergan, & Hesse, 2010; Schreiber & Engelmann, 2010). This approach also reduced the undesirable effect of too much trust between the group members in such tasks in which they would not question the decisions of the others and achieve an inferior result (Engelmann, Kolodziej, & Hesse, 2014). It also guided their communication (Dehler, Bodemer, Buder, & Hesse, 2011) and increased the discussion and processing of unshared information (Engelmann & Hesse, 2011).

However, just making humans aware is not a guarantee that they will change their behavior. They will not necessarily act in a perfectly rational way and try to maximize their utility (Henrich et al., 2001; Kahneman & Tversky, 1979). But humans do commonly use awareness as a tool: Potential employees for a job resolve the asymmetric distribution of information about their qualification between them and the employer by using their acquired education credentials as a signal about their ability level (Spence, 1973).

Creating priority awareness is about tacitly making each party aware of the other's priorities in a negotiation. The awareness tool with which priority awareness is created must first be perceived as something that the negotiators can make use of, and then they have to understand that it is about different priorities, and finally they have to use it to integrate their different priorities in a beneficial way. Priority awareness creates the possibility to bypass an otherwise trial and error search for integrative issues.

3. Experimental study

The goal of our experimental study was to create awareness of the differences in priorities between the negotiating parties, thus promoting more integrative negotiations and, in the end, a better negotiation performance. For this we refrained from explicit instructions or specific training for the negotiators to test if only the awareness is sufficient to change the behavior and improve the performance.

We aimed to foster priority awareness in a computer-supported bilateral (two parties) negotiation. The experimental negotiation support system falls into the definition of an *e-negotiation system* (Kersten & Lai, 2007) as it relies on internet technology for the purpose of facilitating and supporting activities undertaken by negotiators. This experimental negotiations support system was made solely for the purpose of testing the effects of priority awareness and is therefore far away from the functionality of a real live negotiation support system such as "Smartsettle" (iCan Systems Inc., 2015) or other experimental negotiation support systems such as "Inspire" (Kersten & Noronha, 1999) or "Negoisst" (Schoop, Jertila, & List, 2003).

Bar charts seem to be a good choice for fostering priority awareness because they have already been used to visualize priorities of issues (Rangaswamy & Shell, 1997). Rangaswamy and Shell (1997) did not examine its effects because their negotiation support system as a whole was their main research topic. Further, Weber, Kersten, and Hine (2006) discussed the potential use of bar charts to visualize priorities as a means to achieve more integrative agreements. Bar charts lead to better comparisons of values than tables (Jacobs, 1994, 1999) and to more accurate judgments of proportions (Simkin & Hastie, 1987) as well as shorter response times in an information retrieval task (Quispel & Maes, 2014) than other forms of visualization. They are also the advised visualization format for larger numerators (McCaffery et al., 2012). Additionally,

they are commonly used worldwide from regular newspapers to scientific articles for their ease of accessibility.

We used a *graphical decision aid* to test the effect of the underlying concept of priority awareness on different measures of negotiation performance. There are other graphical decision aids conceivable to foster priority awareness than through bar charts, but our intention was to create awareness in a tacit and unobtrusive way. Although visualized two-dimensionally, bar charts represent one-dimensional data e.g. number of sold items or degree of customer satisfaction. Line graphs in comparison, represent two-dimensional data and may be more difficult to understand than other graphs (for an overview see Friel, Curcio, & Bright, 2001). A one-dimensional, well known visualization format like a bar chart could minimize the cognitive load needed to process the visually encoded information (Mayer & Moreno, 2003).

3.1. Measures of negotiation performance

The outcome measures of negotiation that we used are either directly quantifiable measures of economic success or have an implicit effect on negotiations. Our focus lay on the directly quantifiable measures of economic success such as the joint outcome, the pareto efficiency, and the impasse rate because they are generally the primary relevant aspect of real life negotiations. We treated measures with implicit effects such as fairness, satisfaction, and duration as open research questions because we have no informed way to tell how priority awareness will affect them.

The joint outcome, the pareto efficiency, and the impasse rate are widely used to capture the economic success of negotiations (Gettinger, Koeszegi, & Schoop, 2012; Harinck & De Dreu, 2004; Hindriks, Jonker, & Tykhonov, 2011; Hyder et al., 2000; Rangaswamy & Shell, 1997; Thompson & Hastie, 1990) and were thoroughly explained by Tripp and Sondak (1992). The first two are based on preferences, or more precisely, the point scores attached to the different options of all issues that differ between the negotiators. Table 2 helps to understand their calculations as it holds all underlying issues, their options, and the attached point scores for the role of the buyer and the seller.

Taking the fictional car buying/selling scenario from this experimental study as an example, the negotiators have to agree on one option for each of the issues to be negotiated. On the issue “Color” they might agree on the option “White”, on the issue “Delivery date” they might agree on the option “5 months”, and so on with the remaining 6 six issues. Since both negotiators have different priorities through different point scores attached to the options, they achieve a different individual outcome. The sum of the individual outcomes creates the joint outcome. Seen from a macroeconomic perspective, the joint outcome is a simple measure of the created value of a negotiation and increasing, it leads to financial growth of the economy. One negotiator could achieve 6000 points and the other 1200; taken together, both have achieved 7200 points. They could also achieved 4000 and 4200 points, and this taken together amounts to 8200 points. The second example would thus create more value for the economy than the first example.

The pareto efficiency is a numerical value between 0 and 1 and shows whether there are any better individual outcomes for at least one party without them being worse for the other party. Tripp and Sondak (1992) explain the formula for calculating the pareto efficiency. A perfect score of 1 means that there is no other agreement possible which would result in a better individual outcome for at least one party without worsening the individual outcome of the other party. Or put differently: Has there been profit left on the table? To find this out, all possible agreements of a negotiation have to be known. A negotiation with eight issues and five options each results in 390,625 (8^5) different possibilities of agreement which have to be taken into account.

The impasse rate represents the number of aborted negotiations without agreement. Measuring the effects on the impasse rate in negotiations has the caveat that many negotiations have to come to a halt without an external interference. Manipulating impasses would impair natural negotiations and distort the implications on negotiation outcomes. It is up to chance or an enormous number of negotiations to obtain a meaningful amount of impasses to make any valid statements about it.

3.2. Hypotheses and research questions

We hypothesize that priority awareness shows effects consistent with the findings that knowledge about priorities leads to a higher joint outcome (H1, see Table 1 for an overview of all hypotheses; Foroughi et al., 1995; Hyder et al., 2000; Schei et al., 2006; Thompson & Hastie, 1990). We assume that only being aware of the differences in priorities between oneself and the other negotiator – completely uninstructed on how and why to use this information – leads to a better recognition of integrative potential, to more and better trade-offs between integrative issues, and thus to a higher pareto efficiency (H2). As self-disclosure has been shown to result in a lower impasse-rate (Moore, Kurtzberg, Thompson, & Morris, 1999) and priority awareness is accompanied by a kind of self-disclosure about ones priorities, we assume that priority awareness – having a better recognition of integrative potential and the prospect of a higher joint outcome – should also benefit a lower impasse rate (H3).

For the objective and subjective fairness of the agreement, the satisfaction with the negotiation, and the duration of the negotiation, we state the following research questions.

How does priority awareness affect the objective (RQ1a) and subjective fairness (RQ1b) of the agreement? It is possible that being aware of the priorities of the other negotiation party leads to an objectively and subjectively fairer agreement because both negotiators are also aware of the potential losses and gains of the other. With the objective fairness of the agreement, we mean a measurably fair distribution of points. This is sometimes called *contract balance* (Foroughi, 1998; Gettinger et al., 2012). Goh, Teo, Wu and Wei conclude “that contract balance is not a standardized measure of negotiation fairness” (2000, p. 106); we therefore do not calculate the point difference between the individual outcomes in a

Table 1
Summary of hypotheses and research questions.

No.	Hypotheses/Research question
H1	Negotiation pairs with priority awareness agree on a higher joint outcome than those without priority awareness.
H2	Negotiation pairs with priority awareness achieve a higher pareto efficiency than those without priority awareness.
H3	Negotiation pairs with priority awareness arrive at a lower impasse rate than those without priority awareness.
RQ1a/b	Do negotiation pairs with or without priority awareness differ in the objective and subjective fairness of their agreement?
RQ2	Do negotiation pairs with or without priority awareness differ in the satisfaction with their negotiation?
RQ3	Do negotiation pairs with or without priority awareness differ in the duration of their negotiation?

Table 2
Overview Payoff Schedule with all Issues and their Options with Attached Individual Point Scores.

Financing	Points buyer	Points seller	**CO_2 emission**	Points buyer	Points seller	**Warranty**	Points buyer	Points seller	**Delivery date**	Points buyer	Points seller
8%	1600	4000	88 g/km	0	0	6 months	0	1600	5 months	0	2400
6%	1200	3000	126 g/km	−600	−600	12 months	1000	1200	4 months	600	1800
4%	800	2000	164 g/km	−1200	−1200	18 months	2000	800	3 months	1200	1200
2%	400	1000	202 g/km	−1800	−1800	24 months	3000	400	2 months	1800	600
0%	0	0	240 g/km	−2400	−2400	30 months	4000	0	1 month	2400	0
Extras	Points Buyer	Points Seller	**Technology/Audio**	Points Buyer	Points Seller	**Price**	Points Buyer	Points Seller	**Color**	Points Buyer	Points Seller
1	0	3200	None	0	800	24.500 €	−6000	0	Grey	1200	1200
2	200	2400	Audio base equipment	800	600	23.520 €	−4500	−1500	White	900	900
3	400	1600	Multimedia equipment	1600	400	22.540 €	−3000	−3000	Red	600	600
4	600	800	Multimedia equipment + car computer	2400	200	21.560 €	−1500	−4500	Black	300	300
5	800	0	Multimedia equipment + car computer + navigation	3200	0	20.580 €	0	−6000	Silver	0	0

The buyer and the seller could only see their own point scores during the negotiation, independent of the condition. There were no restrictions made on the communication of the negotiators, including the sharing of any of this information.

negotiation pair but the percentual difference between the individual outcomes in a negotiation pair. Dividing the contract balance by the joint outcome gives a percentual difference between the negotiators in a pair independent of the amount of their achieved joint outcome and thus makes all the pairs comparable. With the subjective fairness of the agreement, we mean the perceived fairness of the parties after the negotiation. This could hypothetically be different from the objective fairness, but we have no reason to believe so.

How does priority awareness affect the satisfaction with the negotiation (RQ2)? The satisfaction with the negotiation is a strong predictor of the willingness for future negotiations with the same partner (Oliver, (Sundar) Balakrishnan, & Barry, 1994). It is possible that the parties are more satisfied with the negotiation when they are made aware of the priorities of their negotiation partner because this avoids the intrusion of asking the other about his or her priorities and gives a hint on his or her honesty. There is also the chance that the negotiators are not happy about the fact that the other is aware of their true priorities and that they cannot engage in strategic misrepresentation of information to gain an advantage over the other negotiation party (Steinel & De Dreu, 2004).

How does priority awareness affect the duration of the negotiation (RQ3)? Jarvenpaa (1989) showed that graphical decision aids speed up the decision making time when they are congruent with the task. The bar charts in both conditions, with and without priority awareness, have a different amount of information but are both task congruent in visualizing the priorities that play a substantial role in negotiations. The pairs with priority awareness have the advantage of also seeing each other's priorities; they do not have to ask for the priorities and can directly concentrate on the most important issues. Therefore, they can potentially arrive faster at an agreement. The additional processing of the priorities of the other negotiation party does take more time, on the other hand, and hence, this could eliminate the potential time advantage of priority awareness.

This experiment was carried out in Germany; therefore, we have translated all presented screenshots of the experimental negotiation interface into English.

4. Method

4.1. Participants and design

A sum of 132 university students from different fields of study (69 female, 63 male, $M_{age} = 24.96$, $SD_{age} = 7.31$, age range: 18–62) successfully and voluntarily participated in this experimental study and were paid an hourly rate of 8 €. All participants were randomly assigned to either the role of a car seller or the role of a potential buyer. This resulted in 66 pairs. These pairs then were randomly assigned to either the experimental condition with priority awareness or the control condition without priority awareness, resulting in 33 pairs per condition. The distribution of gender in the pairs was controlled for. These numbers are after the exclusion of two pairs who had serious problems understanding the negotiation task and did not generate valid data that could be included in the calculations.

4.2. Material

The material used in this experiment was a modernized version of the payoff schedule for a car buying/selling scenario of Thompson and Hastie (1990). Using a payoff schedule is common practice in most experimental negotiation studies in which the participants have to take over a role in a scenario and negotiate predefined issues (e.g. Hyder et al., 2000; Thompson & Hastie, 1990; Van der Schalk et al., 2009). This ensures identical preconditions for all negotiators and makes different hypotheses examinable. All participants receive a table with the issues to be negotiated as well as the different options for the issues, depending on their role in the negotiation. Every option has an attached point score and the goal for every negotiator is to maximize the sum of their individual point scores. A full overview of the used payoff schedule can be seen in Table 2.

With respect to the differences between the original and our payoff schedule, we did not change the distribution of point scores between the issues and the amount and order of point scores of the options by themselves. We had to modernize the descriptions of some of the eight issues and five respective options; for example, we changed the original issue “Radio” with its options “None”, “AM”, “AM/FM”, “AM/FM/Tape” and “AM/FM/Tape+” to the issue “Technology/Audio” with the options “None”, “Audio base equipment”, “Multimedia equipment” “Multimedia equipment + car computer” and “Multimedia equipment + car computer + navigation” (a comprehensive list of changes is available upon request).

Four issues were integrative and could be profitably traded between the negotiators: Financing, Warranty, Extras, and Technology/Audio. Two issues were distributive, meaning that both negotiators wanted exactly the opposite option to gain the same amount of points: Delivery date and Price. For example, the seller

would get 0 points for the option “1 month” in the issue “Delivery date” and the buyer 2400 points. For the option “5 months” it was the other way around. The two remaining issues “CO_2 Emission” and “Color” were compatible: Both negotiators had the highest point score on the same option of an issue; in other words, they wanted the exactly same thing. The sum of the individual point scores could possibly range from −3600 to 13200 points of joint outcome.

The priorities and their visual representation in form of bar charts were created by ranking the issues by the option with the highest point score for the respective negotiator. At this point, we should mention that there is one special case: Only the modulus of the highest scoring option is important for the creation of priorities. The seller's loss of the highest scoring option “20,580 €, -6000 points” of the issue “Price” is higher than the gain of the highest scoring option “5 months, 2400 points” of the issue “Delivery date” and therefore “Price” would be of higher priority than “Delivery date”. Such negative point scores are omitted in many experimental negotiation studies but have a valid reason to exist. Sometimes negotiators do not only have to agree on who gains more but also on who loses less.

This approach of creating priorities by ranking the issues by the modulus of their highest scoring option is also followed by Raiffa, Richardson, and Metcalfe (2002 p. 214) in the evaluation of two-party integrative negotiations.

4.3. Procedure and operationalization

The duration of the entire experiment was approximately 1 h; timestamps were logged. It took place completely in an experimental negotiation support system created specifically to test the impact of priority awareness. Fig. 1 holds an overview of the procedure of the experiment.

4.3.1. Introduction and questionnaires

At first, when the participants arrived in the waiting room, they were greeted by the experimenter and briefed shortly about the procedure of the experiment as follows: They would work alone in separate rooms. Everything would take place on the computer in front of them and they would also see all instructions on the monitor. They would work alone until the negotiation phase when they would have to put on a headset for communication. After the negotiation phase, both negotiators would once again work separately.

Before the experiment started, the participants were asked first to fill out a declaration of consent informing them about which data will be gathered about them, how it will be used, and that they can – without any drawbacks – always abort the experiment and retract their data.

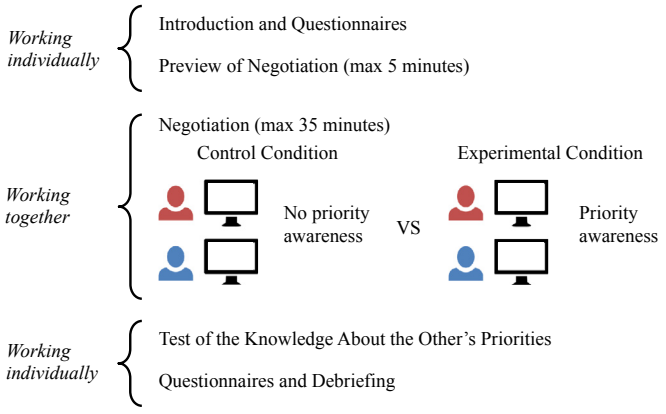

Fig. 1. Overview of the experimental procedure.

The experiment began with questions on control measures. First, the participants filled out a questionnaire about personal data such as the field of study, gender, age, prior knowledge of bar charts/tables/computers and its frequency of usage, and acquaintance with the other negotiator. This was followed by other questionnaires which were not relevant for testing the hypotheses of this study. All questions in this study were assessed by four-point rating scales ranging from 1 point for no agreement and 4 points for complete agreement except of field of study, gender and age, which were open questions.

4.3.2. Preview of negotiation

Next, the negotiation scenario and the individual role were described for the first time (here exemplary of the seller):

> You want to sell a car and are negotiating with the buyer. You have to agree on 8 issues: Financing, CO_2 Emission, Warranty, Delivery date, Extras, Technology/Audio, Price and Color. Every issue has 5 options with different point scores. You are negotiating for points: Your goal is to maximize your own points!

The instruction to maximize their individual points should create a more realistic negotiation scenario and reinforce their intrinsic motivation to win (Deci, Betley, Kahle, Abrams, & Porac, 1981).

After this initial briefing, a preview of the experimental negotiation support system was presented (nearly identical to Fig. 3). It allowed the participants to become familiar with the upcoming negotiation interface as well as their priorities and point scores. To engage the participants with their payoff schedule, we asked them to assign priority numbers to each issue. In the top half of the screen, every participant saw a bar chart with his or her priorities and in the bottom half of the screen, a table with the eight issues and their respective options depending on their role as either car buyer or seller. The participants were asked to choose the correct priority for each issue from a drop-down menu under every issue/bar of the bar chart. The specific instructions shown during the preview were:

The more points you can win/lose on an issue, the more important the issue is and the taller the bar is. Assign correct ranking numbers to the issues according to their importance. Begin with the most important issue with rank 1. You have to assign the rank 4 twice so that the least important issue can be given the rank 7. Only then can you click on “Forward” (or you will be automatically forwarded after 5 min)!

No further information was given on behalf of the bar chart except enough to make sure that the participants knew what the bar chart represented. However, they were not informed about its potential benefits so as to not impair the potential effects of awareness, which was precisely what we wanted to test.

4.3.3. Negotiation

After the preview, the negotiation scenario and each individual role were described for a second time but with further instructions on the negotiation interface: Every negotiator could independently click on the options which would be seen as marked by both. They could also freely change this marking, independent of who set it. Marking options would be there to help them during negotiation but also to save their final agreement. The order of options each negotiator would see differed from the other. The negotiation could be aborted at any time by clicking on “Forward”. The negotiation would end automatically after 35 min. After the negotiation they

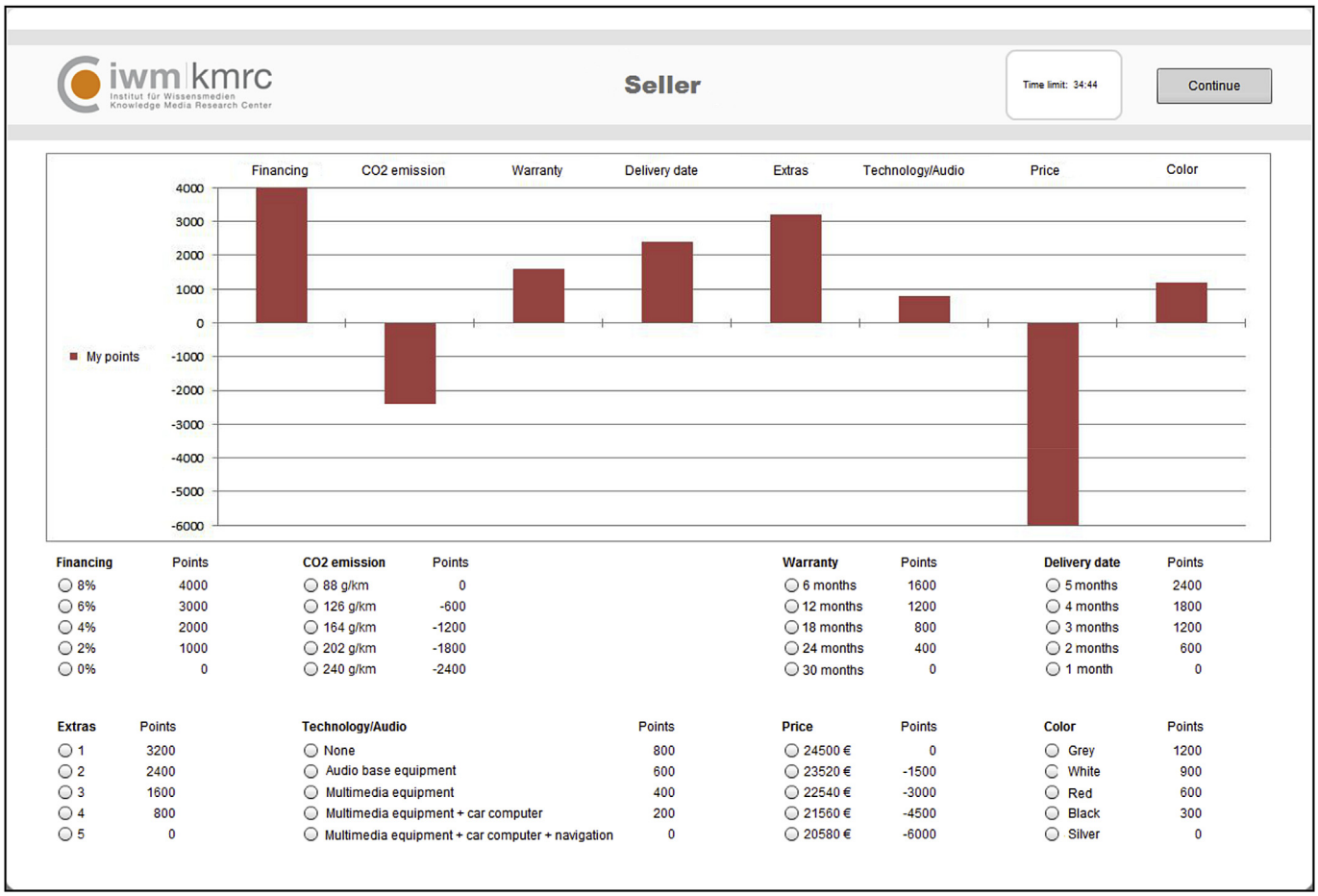

Fig. 2. Negotiation phase in the control condition without priority awareness (as seen by the car seller).

would be asked, if they had come to an agreement.

The Figs. 2 and 3 show a screenshot of the experimental negotiation support system exemplary for the car seller. The negotiators could use their headset to communicate through a Skype connection, which was recorded and only lasted for the duration of the negotiation phase (audio-only communication; Bazerman, Curhan, Moore, & Valley, 2000). There were no constraints on the topics that the negotiators could talk about. They were free to carry out the negotiation and communicate as they wished, including the sharing of priority information. Both conditions should potentially have access to the same information so any found differences between the negotiation pairs would be due to priority awareness.

To test the impact of priority awareness, the negotiators in the control condition saw a bar chart in the upper half of the screen, which only visualized their own priorities (Fig. 2). The maximal gain or loss that the negotiators could achieve with an issue determined its importance and priority: The taller the bar, the more points they could gain or lose with an issue and, consequently, the higher the priority of an issue. The negotiators in the experimental condition saw a bar chart in the upper half of the screen which visualized their own priorities as well as those of the other negotiator (Fig. 3). Besides this difference in the upper half of the screen, there were no differences between the control and the experimental condition.

Depending on their role as car buyer or seller, both parties only saw a table with their own preference scores for the five options of each one of the eight issues in the lower half of the screen. The options were accompanied by radio buttons which either negotiator could mark by clicking on it. For example: Did the seller not agree with a marked option of the buyer – for instance, a very low price which has a low point score for the seller – he or she could click freely on another option, preferably a higher price, which had a higher point score for the seller. This could go back and forth until they finally agreed on one marked option of this issue. Every marked option was logged by the negotiation support system and afterwards, the joint outcome, the pareto efficiency, as well as objective fairness could be calculated.

To evaluate whether the negotiation ended in an agreement or an impasse, a single yes/no question on whether the negotiators reached an agreement on all issues was presented to each negotiator individually after the negotiation.

4.3.4. Test of the knowledge about the Other's priorities

A test of the knowledge about the other's priorities was applied afterward to assess whether a negotiator remembered the priorities of his or her partner. This procedure stems from the studies by Engelmann et al. (Engelmann & Hesse, 2010; Engelmann et al., 2010; Schreiber & Engelmann, 2010). centering around learning and problem solving and in which participants had to assess the extent of the knowledge that one group member gained about the others. The negotiators had to select the priorities of the issues of their partner. Every one of the eight issues was listed and accompanied by a drop-down menu with again a choice of ranking numbers ranging from 1 to 7.

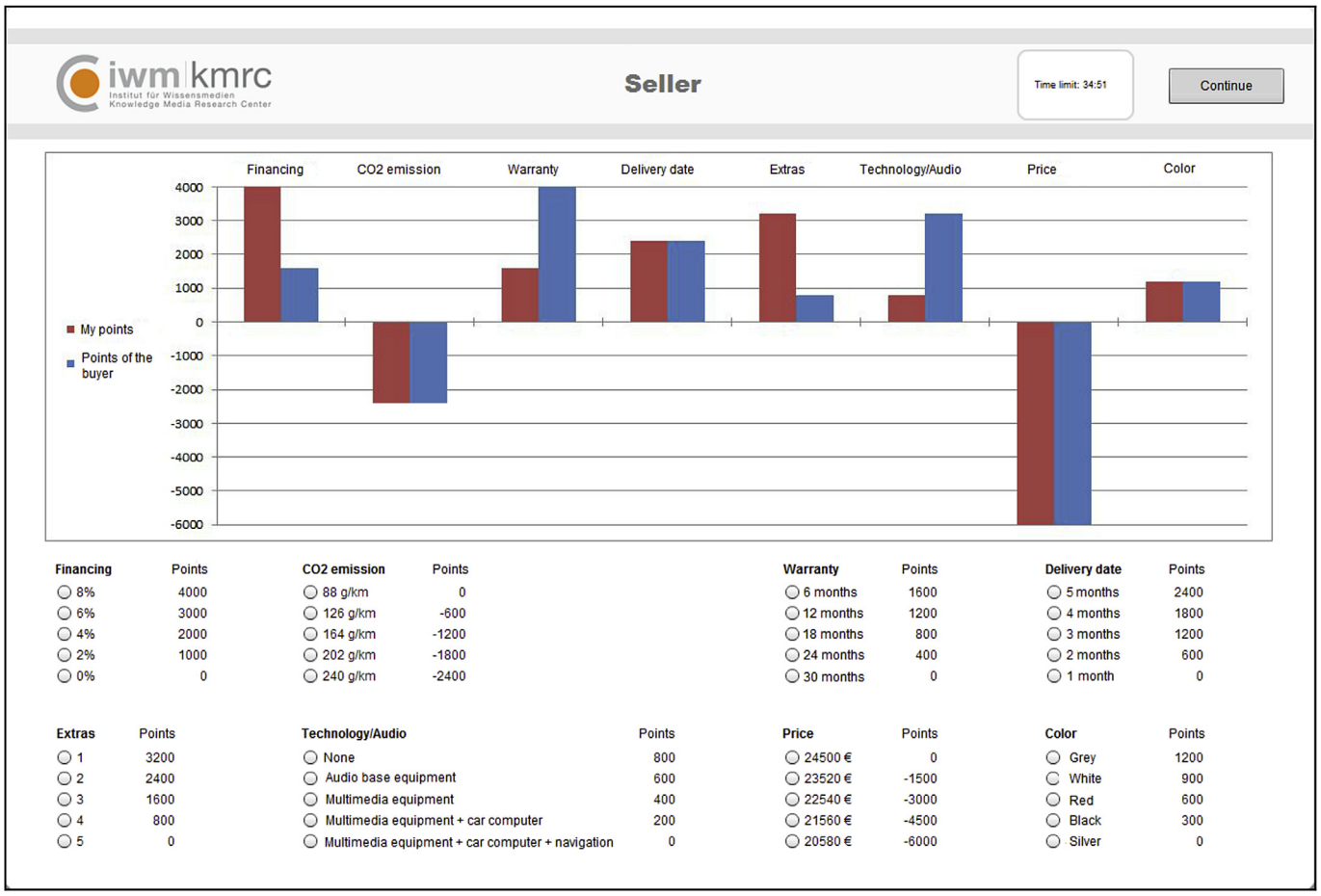

Fig. 3. Negotiation phase in the experimental condition with priority awareness (as seen by the car seller).

4.3.5. Questionnaires and debriefing

Finally, the participants were asked to answer four questions on their satisfaction with the negotiation and two questions on their perceived fairness of the agreement. For measuring satisfaction, the questions were "I am satisfied with the outcome of our negotiation" and "I am not satisfied with our agreement" as well as "I am satisfied with the process of our negotiation" and "Our negotiation could have run better". These were intended to measure the satisfaction with the agreement and the satisfaction with the process of the negotiation but the participants did not distinguish between the result and the process and therefore these four questions constitute the general satisfaction with the negotiation. For measuring subjective fairness, the questions were "I think the outcome of our negotiation is fair" and "I think the agreements made in our negotiation are unfair". Although considered to be control measures, we asked two questions each about the frequency of previous negotiations after the negotiation as to not influence the negotiation performance: "Before participating in the study I have often negotiated" and "Before participating in the study I rarely negotiated". Further questions on supplementary measures were asked, which do not fall in the scope of the stated hypotheses here.

At the end, the participants were paid and shortly debriefed.

5. Results

For the analyses of all hypotheses, except the one concerning the impasse rate, we followed the advice of Tripp and Sondak (1992) and excluded all pairs which stated an impasse and therefore did not achieve any interpretable outcome. This approach left 60 pairs in the sample ($n_{EC} = 28$, $n_{CC} = 32$). Substituting a non-agreement with a zero or mean point score distorts the results because such pairs did not agree on a zero or mean point score but did not agree at all. We used the aggregated data of the negotiation pairs for all analyses because the individuals were not independent of each other (Cress, 2008). Depending on whether the assumptions of different statistical methods such as, for example, a normal distribution of values or the homogeneity of variance were met, we either calculated a t-Test, a Wilcoxon rank-sum test, a pairwise Wilcoxon rank-sum test with a p-value adjustment by Holm (1979), or a Chi-squared test with their appropriate effect sizes to compare the performance of the conditions.

There were no significant differences on the group level in terms of the control measures. We assessed the level of experience of the negotiators by looking at their individually stated frequency of previous negotiations. The participants were "rather unexperienced" ($M = 2.39$, $SD = 0.86$) in negotiating.

The results confirm Hypothesis 1: Pairs with priority awareness agreed on a higher joint outcome ($M = 9793$, $SD = 1960$) than pairs without priority awareness ($M = 8775$, $SD = 1890$, $t(58) = 2.05$, $p = .045$, $d = .53$). This makes up for a difference in the mean of 12%.

The pairs with priority awareness also achieved a marginally higher pareto efficiency in their negotiation ($M = .959$, $SD = .13$) than the pairs without priority awareness ($M = .935$, $SD = .12$, $W = 568.5$, $p = .074$, $r = -.23$). This makes up for a difference in the mean of 2.4%.

Contrary to Hypothesis 3, pairs with priority awareness arrived at a marginally higher impasse rate ($n = 5$) than pairs without priority awareness ($n = 1$, $\chi^2(1, N = 66) = 2.93$, $p = .087$, $\varphi = .21$). This result will be discussed thoroughly below.

We found the following results with respect to the research questions about the effects of priority awareness on the outcome measures of negotiations, objective and subjective fairness of agreement, satisfaction with the agreement, and duration of negotiation: With regard to the first research question, we found no difference in the duration of the negotiation between pairs with priority awareness ($M = 12{:}03$ min, $SD = 07{:}19$ min) and pairs without priority awareness ($M = 11{:}31$ min, $SD = 06{:}07$ min, $W = 548$, $p = .970$).

We also did not find any difference in the satisfaction with the negotiation between pairs with priority awareness ($M = 3.05$, $SD = .33$) and pairs without priority awareness ($M = 3.07$, $SD = .41$, $t(58) = -0.22$, $p = .828$). Pairs of both conditions were "rather satisfied" with their negotiations.

Although it seems that pairs with priority awareness achieved an objectively fairer agreement ($M = 36.7\%$, $SD = 34.0\%$) than pairs without priority awareness ($M = 50.9\%$, $SD = 49.7\%$, $W = 361$, $p = .197$) they did not differ significantly. They also did not differ in the subjective fairness of agreements ($M_{EC} = 3.23$, $SD_{EC} = .49$, $M_{CC} = 3.27$, $SD_{CC} = .43$, $W = 440$, $p = .904$) which both conditions stated as "rather fair".

The transcription of the audio recordings of the negotiations resulted in 7911 lines of utterances which were independently coded by two raters on three variables, with either a 0 or a 1: (1) Reference to the bar chart, for example, "We can take financing and warranty; it seems as if we both have a large and a small bar." (2) Reference to priorities, for example, "It's more important for me that the CO_2 emission is alright. The color is not important to me at all." (3) Reference to point scores, for example, "Yes, how many points do you get for multimedia equipment and car computer?"

Cohen's Kappa for two raters showed moderate to substantial agreement (Landis & Koch, 1977) between the independent raters with $\kappa_{RefBarChart} = .56$, $\kappa_{RefPriorities} = .64$ and $\kappa_{RefPreferences} = .61$. In the following step, the raters agreed on one correct rating for each utterance by working through the whole transcription together. This unified rating was used for the next calculations.

Pairs with priority awareness referred to the bar chart more often ($SUM = 154$) than pairs without priority awareness ($SUM = 32$, $W = 7581658$, $p < .001$, $r = -.10$). They also referred to priorities more often ($SUM = 198$) than pairs without priority awareness ($SUM = 141$, $W = 7724479$, $p = .023$, $r = -.03$). Both conditions did not differ in their reference to point scores ($SUM_{EC} = 600$, $SUM_{CC} = 538$, $W = 7789097$, $p = .789$).

No significant differences on the group level were found in the test of the knowledge about the other's priorities and in any of the supplementary measures.

6. Discussion

The knowledge about the priorities of a negotiation partner is assumed to have a high impact on the economic outcome of a negotiation because it creates the possibility of an integrative agreement in which the negotiators give in on less important issues and, in exchange, take on more important ones. Until now, no study has systematically tested the effect of making the negotiators only aware of the differences between their priorities on different measures of negotiation outcome. Our goal was to create this priority awareness with an intervention so trivial that it could be implemented with minimal effort. We therefore used ordinary bar charts as known from business reports or school books. None of the negotiators was instructed on how or why to use the bar charts and none of them was kept from freely exchanging any information whatsoever. Would the negotiation pairs perceive the bar charts as an awareness tool, would they understand its benefit and would they use it for making more trade-offs to achieve a better negotiation performance?

The results of 66 computer-supported negotiations between the roles of a car buyer and seller have shown that negotiation pairs, which were made aware of the priorities of their negotiation partner, negotiated an averaged 12% higher joint outcome than pairs which were not made aware of the priorities of their negotiation partner. Pairs with priority awareness tended to arrive at averaged 2.4% more pareto efficient agreements, leaving less profit on the table. Surprisingly, pairs with priority awareness might have been slightly more likely to abort the negotiation than pairs without. Priority awareness does not seem to have any negative effect on the measures stated in the open research questions. Both conditions did not differ in the duration of the negotiation, the objective or subjective fairness of the agreement, or their satisfaction with the negotiation.

It is possible to make negotiators aware of each other's priorities in a tacit and unobtrusive way. The results of the study speak for the effectiveness of the priority awareness approach: A minimal intervention improves joint outcome and the pareto efficiency and has no drawbacks on satisfaction, fairness or duration. It would be possible to integrate this approach – creating priority awareness through bar charts – in existing negotiation support systems, at least in an optional way. Furthermore, a specialized negotiation support system is not needed for real life negotiations in order to make use of priority awareness. Agreeing on using this approach and a spreadsheet program are already sufficient to improve the negotiation performance. It is even conceivable that both parties agree to draw bar charts representing their priorities of issues on a single sheet of paper. The usage of a spreadsheet program or a single sheet of paper needs at least one negotiator who in fact knows about the benefits of priority awareness. Hence, these low-tech approaches are only applicable for more experienced negotiators.

Further, this approach is not about negotiations over the distribution of a product alone but about decision making in general. The use of a negotiation support system with an optional priority awareness function would be advisable and every improvement of the agreement would benefit all parties. An example would be different departments of one organization, which clearly have the common goal of success for the organization although they have different priorities. Being aware of these differences and using them for integrative decision making would benefit the organization as a whole and, in return, all of the departments. The feasibility of this idea was shortly presented by Thiemann and Engelmann (2015).

Regarding bar charts, it becomes obvious how omnipresent they are in everyday life. They are quick to make and seem easy to understand. But the ability to correctly read and interpret even ordinary bar charts is not necessarily intuitive and has to be learned. This study gave us a hint that some people had at least initially difficulty understanding the bar chart and therefore they could have lacked the advantage of those with a higher aptitude for this type of visual literacy. Especially in business settings, it is crucial to be able to read bar charts, understand them, and to react to their information in order to make adequate decisions. Organizations also use bar charts to portray their performance in a better light (Beattie & Jones, 1992). Thus a critical examination of bar charts would not only be wise for the sake of fostering priority awareness to improve negotiations but also in many other business related situations. Such visual literacy is taken for granted because we are exposed to bar charts ever since entering school. There is no special

emphasis in schools on teaching visualizations or graphical decision aids, but as we strongly rely on them to simplify and aggregate information for us to make decisions, it would be advisable to at least in some way address the task of reading, understand, and interpreting graphical decision aids.

Somewhat imitating in this study was, that the participants were rather unexperienced in terms of negotiations. The effectiveness could be even higher in real life negotiations. People negotiating for a living could have taken more out of the awareness of the priorities of the others. They have the experience needed to understand this information better and to make better use of the integrative potential of the negotiation. On the other hand, it has been shown that even unexperienced negotiators without training could make beneficial use of priority information when made aware about them.

We would like to point out that the influence of priority awareness on the impasse rate has never been measured in this way before and that it is only meaningfully interpretable if enough impasses occur naturally. If it would not have been counter hypothetical, this result could have been ignored because the total number of impasses was so low that it can only be interpreted in a descriptive way. Nevertheless, a possible explanation could be that fostering awareness of the priorities of the other party works well in making the integrative potential of the negotiation visible, but the possible unwillingness of one negotiator to make concessions – even though his or her priorities are available to the other – would lead the other negotiator to abort the negotiation. Future studies will show whether this is a recurring phenomenon or just a coincidence in the sample of participants.

This experiment has shown that the bar charts in our study had their own share of drawbacks in their simplicity. An informal questioning of the participants after the experiment showed that many expected an interactive instead of a non-interactive bar chart. They were surprised that the bars did not change in size in correspondence to the marked options in the negotiation because they were accustomed to more interactivity in a computer-supported environment. A non-interactive bar chart has now been proven to successfully foster priority awareness, but it may not deliver enough information in a computer-supported environment for the negotiators and also has its limitations as it does nothing to resolve the incompatibility error (Thompson, 1991). Forty-five percent of all pairs did agree at least in one of two compatible issues on an option that was suboptimal for both negotiators although both preferred the identical option. They agreed on a joint loss. In our next study, we plan to use interactive bar charts to foster priority awareness and compare them to the non-interactive bar charts. This interactivity could create not only a better awareness about priorities but also another quality of awareness. The negotiators would not only be made aware of the different priorities of issues but also of the different priorities of options, as the bars would change in size according to the marked options in the negotiation. This could result not only in an even better negotiation performance but, while creating awareness for differences between issues, also create awareness for the similarities between issues and help to resolve the incompatibility error.

For the present study and the planned study with interactive bar charts, we assume a state in which negotiation parties truthfully and openly share all the information about their priorities. Negotiations here take place in a manner of a full, open, truthful exchange (FOTE; Raiffa et al., 2002) which is also assumed in other studies (e.g. Herath, Bremser, & Birnberg, 2010). This can be considered a limitation of this study because although negotiations take place in such a manner, the case of a partial open, truthful exchange (POTE), in which not all information is shared, is prevalent in real life negotiations. After we have established that priority awareness improves negotiation outcomes at the level of the issues in this study, and we have evaluated whether it works better on the additional level of options in a second study, we will address the partial open, truthful exchange of priorities in a third study on priority awareness. This will further validate the priority awareness approach and make way for its implementation in existing negotiation support systems and for its broad usage in a computer-supported environment to enhance integrative decision making in a multitude of natural settings.

6.1. Conclusion

A trivial bar chart including the priorities of the other negotiator is enough to improve the negotiation performance, without negative consequences on satisfaction, fairness and duration. This kind of awareness is enough, there are no further instructions needed. Such a simple and inexpensive way to improve – not only – computer-supported negotiations could easily be integrated as an optional feature in existing professional negotiation support systems and benefit its users.

Author note

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Preventing undesirable effects of mutual trust and the development of skepticism in virtual groups by applying the knowledge and information awareness approach

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Abstract Empirical studies have proven the effectiveness of the knowledge and information awareness approach of Engelmann and colleagues for improving collaboration and collaborative problem-solving performance of spatially distributed group members. This approach informs group members about both their collaborators' knowledge structures and their collaborators' information. In the current study, we investigated whether this implicit approach reduces undesirable effects of mutual trust and mutual skepticism. Trust is an important influencing factor with regard to behavior and performance of groups. High mutual trust can have a negative impact on group effectiveness because it reduces mutual control and, as a result, the detection of the others' mistakes. In an empirical study, 20 triads collaborating with the knowledge and information awareness approach were compared with 20 triads collaborating without this approach. The members of a triad were spatially distributed and participated in a computer-supported collaboration. The results demonstrated that the availability of the knowledge and information awareness approach overrides the negative impact of too much mutual trust and counteracts the development of mutual skepticism. This study contributes to further clarifying the impact of trust on effectiveness and efficiency of virtual groups depending upon different situational contexts.

Keywords Computer-supported collaborative problem solving · Group awareness · Knowledge and information awareness · Mutual skepticism · Mutual trust

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Introduction

Different lines of research (e.g., Nickerson 1999; Wegner 1986) highlight the importance of knowing what collaborators know in order to communicate and collaborate effectively. However, the process of acquiring such knowledge is prone to errors (e.g., Nickerson 1999) and the acquisition of such knowledge needs time (Wegner 1986). Engelmann and colleagues have developed a solution for this problem: Their knowledge and information awareness approach (KIA approach) assists spatially distributed group members in acquiring knowledge about their collaborators' knowledge structures and the information underlying these structures in an effective and efficient way (e.g., Engelmann and Hesse 2010; Engelmann et al. 2010). Therefore, they define knowledge and information awareness (KIA) as being informed about the collaboration partners' knowledge structures and about the partners' information underlying these structures (e.g., Engelmann et al. 2010). The acquisition of KIA is enhanced by digital concept maps that visualize both the collaborators' knowledge structures and the information underlying these structures (see Fig. 1). These concept maps are provided to the group members while they are participating in a computer-supported collaboration.

Concept maps are a well-proven kind of knowledge visualization consisting of hierarchically ordered labeled nodes and labeled links between these nodes (Novak and Gowin 1984). Digital concept maps moreover allow for adding hyperlinks for accessing further information (e.g., Alpert 2005).

The studies by Engelmann and colleagues demonstrated that this KIA approach not only improves collaborative problem solving of virtual groups – that is, groups with spatially distributed group members – but also can help to overcome several collaboration barriers (e.g., Engelmann and Hesse 2011; Engelmann and Kolodziej 2012; Schreiber and Engelmann 2010).

Another collaboration barrier refers to the concept of mutual trust. Trust is an important influencing factor with regard to behavior and performance of groups (Salas et al. 2005). According to Mayer et al. (1995) trust refers to "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party" (p. 712); that is, one group member has to believe that another group member will perform the needed activity in order to accomplish a common task.

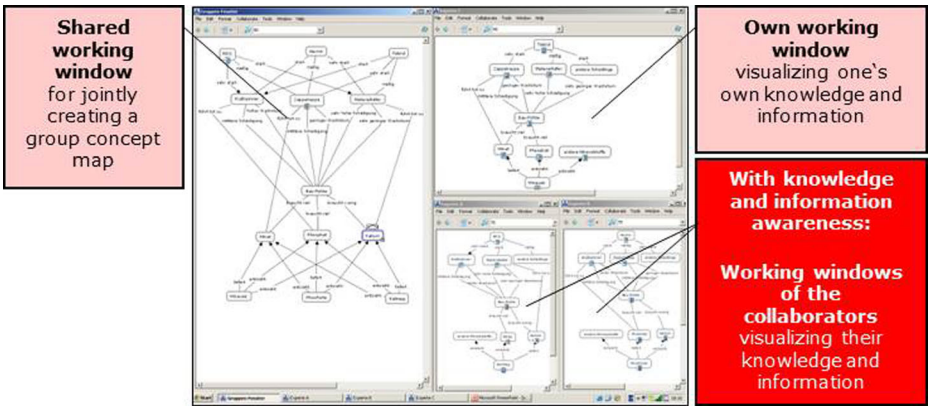

Fig. 1 Computer screen of the experimental condition with a KIA approach

Imagine a situation in which several people, having different domain expertises, were ordered to solve an acute environmental pollution problem: They are highly busy and work at different institutions. Therefore, they have to collaborate via computers. In addition, they do not know each other and thus do not know what the others know – a problem that could be solved with the KIA approach. Moreover, all experts differ in the amount of general trust they have in others, also called trust propensity (trust as a trait) (e.g., Colquitt et al. 2007). Thus trust is likely to affect the collaboration. In addition, mutual trust can be developed through collaboration (trust as a state) (cf. Aubert and Kelsey 2003).

Our current study addressed group situations like the one described and investigated the impact of mutual trust in virtual groups on group performance depending on whether the KIA approach is available or not (trust as a predictor). In addition, it investigated whether – depending on the availability of the KIA approach – differences in the amount of collaboration quality have an impact on the developed trust after the collaboration phase (trust as criterion).

In this paper, we will start by highlighting the challenges of computer-supported collaboration, especially the need for fostering the acquisition of knowing what collaborators know. We will then explain how the KIA approach solves this problem and why it is able to help to overcome several collaboration barriers, especially the barrier with regard to mutual trust. Subsequently, we will present our experimental study. The paper ends with a discussion as well as with explicating implications.

Challenges of computer-supported collaboration

The need for collaboration, especially between persons in different fields, is ever rising in our information age, and certainly the geographical dispersion of different experts can be overcome by using, for example, specialized groupware. Groupware can also address the social element of computer-supported collaborative learning (CSCL) such as explicating thoughts, actively discussing views, and coordinating actions (Kirschner and Erkens 2013). To bridge the research gap between computer-supported cooperative work (CSCW) and CSCL, Fransen et al. (2013) summarized variables mediating group effectiveness and applied these findings from CSCW research to the field of CSCL. While there are differences between working- and learning-teams, many similarities make knowledge gained in a CSCW setting applicable to a CSCL setting and vice versa.

There are several advantages of computer-supported collaboration (cf. Engelmann et al. 2009; Janssen and Bodemer 2013; Kirschner and Erkens 2013), but it is not easily achieved in an effective way. Interaction problems, especially regarding communication and coordination may occur (Janssen et al. 2007): For example, a reduced amount of communication channels may hinder coordination (e.g., Smith et al. 2011), provided communication capabilities may be rarely used (Lambropoulos et al. 2012) or misused (Baker et al. 2012). According to Kirschner et al. (2008) learning often does not take place in CSCL settings, because the tasks are not suited for collaboration, the computer-supported environment is not suited to support learning, or the social conditions that are necessary for good collaboration do not exist. In this current paper, we refer to the last reason: A difficulty for virtual groups is that often the members do not know each other before they have to collaborate on a common task, and therefore, they do not know what their collaborators know. However, different lines of research have demonstrated the importance of knowing what collaborators know (cf. Engelmann and Hesse 2010): Research on *Audience Design* (e.g., Dehler-Zufferey et al. 2011) gives evidence that individuals adapt their texts depending upon the addressee. According to the *Knowledge Imputing* approach (Nickerson 1999), effective communication requires a sufficient amount of correct

knowledge about the communication partner's knowledge. If one overestimates the partner's knowledge, the partner might not be able to understand the statements anymore (Nickerson 1999). This is also highlighted by Beers et al. (2005) who pointed out that members of a multidisciplinary group "need to find some kind of commonality between their different perspectives in order to benefit from each other" (p. 624). Studies on the *Theory of Transactive Memory System* (Wegner 1986) confirm that the groups whose members know who is an expert on which topics achieve more in-group tasks (e.g., Liang et al. 1995).

Prior research has shown that it is not easy to acquire correct knowledge about the collaboration partner's knowledge: During this process, a lot of perception or evaluation mistakes can slip in (Nickerson 1999). In addition, according to the theory of transactive memory system (Wegner 1986) sufficient common time is required to acquire this knowledge. Furthermore, there are situations in which the possibilities of acquiring knowledge about the partners' knowledge are strongly restricted (Engelmann and Hesse 2010), for example a CSCL setting with a reduced amount of communication channels (cf. Baker et al. 2012; Lambropoulos et al. 2012).

The approach for fostering knowledge and information awareness

In order to find a solution to the need for and the problem of acquiring knowledge about the collaboration partners'knowledge in computer-supported collaborative settings, Engelmann (née Keller) and colleagues developed their KIA approach (Keller et al. 2006). It provides, as mentioned above, the spatially distributed group members with their collaborators' knowledge structures and their collaborators' information underlying these structures, both visualized by means of digital concept maps (e.g., Engelmann and Hesse 2010).

Empirical studies confirmed that this approach not only leads to an easy and quick acquisition of KIA, but also to an improvement of collaborative problem solving (e.g., Engelmann and Hesse 2010). Because it has been proven that collaborative problem solving fosters learning (e.g., Hausmann et al. 2004), one can expect that this approach also increases learning. This was tested in a recent study by Lechner and Engelmann in which the KIA approach was applied in a school setting to improve learning in biology. This data is being analyzed at the moment.

That knowledge awareness increases has also been confirmed by studies using other approaches: For example, Bodemer's (2011) knowledge awareness approach marginally improved individual learning gains as well as collaborative learning performance. In his experimental condition a learner was provided with his own solution together with the learning partner's solutions in the context of a multiple external representation task, while in his control condition the dyad members only saw their own solutions. In the study by Nückles and Stürz (2006) self-ratings regarding the expertise of laypersons were provided to the experts. As a result, the communication between the expert and the layperson was more efficient, compared to a condition without this knowledge awareness tool. This improved communication led to laypersons acquiring more procedural and declarative knowledge.

Empirical results demonstrated that the KIA approach may also assist in overcoming collaboration barriers: With the study by Engelmann and Hesse (2011) evidence was provided showing that the KIA approach fostered sharing and cognitively processing of unshared information. In the study by Schreiber and Engelmann (2010), it was shown that this approach fostered the development of a transactive memory system. Further effects of knowledge awareness approaches in CSCL are summarized by Janssen and Bodemer (2013). In the current paper, we focus on investigating a collaboration barrier having to do with the concept of mutual trust.

The impact of mutual trust on behavior and performance of groups

Trust is an important influencing factor regarding behavior and performance of groups (Salas et al. 2005). It can lead to more helping behaviors in CSCL groups (Hsu et al. 2011) and is seen as a crucial part of CSCL by Kirschner and Erkens (2013). Changes in the situation can have an impact on the role of trust in groups (e.g., Kramer 1999). For example, the role of trust is dependent on the degree of structure in the situation (Dirks and Ferrin 2001; Jarvenpaa et al. 2004), that is, the degree of freedom regarding the group members' activities: In situations with a low degree of structure, trust has a direct effect on group variables. In such situations, it is difficult to interpret others' behaviors. Therefore, their behavior is interpreted depending on the amount of trust the group members have with each other. In situations with a moderate degree of structure, trust is a moderating factor. Factors for interpreting others' behaviors are given; however, trust influences how these factors are interpreted. In situations with high structure, others' behaviors can be directly evaluated. Trust is not used to interpret others' behaviors and, therefore, does not have any impact on group measurements.

In situations, in which trust has an effect on group variables, the following relations are to be expected: In numerous publications (e.g., Jarvenpaa et al. 1998), it is argued that mutual trust is an important influencing factor for group effectiveness. This was also confirmed by several empirical studies (e.g., Colquitt et al. 2007; Kanawattanachai and Yoo 2002; Paul and McDaniel 2004). Further empirical studies, for instance by Aubert and Kelsey (2003) as well as Jarvenpaa et al. (2004), have shown that trust has an effect on group efficiency, but not on group effectiveness.

These contradictory results could possibly be explained by another influencing factor, namely, correctness of individual performances: If group members with *high mutual trust* work without mistakes, this should result – according to Aubert and Kelsey (2003) as well as Jarvenpaa et al. (2004) – in a faster and, therefore, more efficient collaboration, since it is to be expected that high mutual trust reduces mutual control. When free from errors, high mutual trust should not have an impact on group effectiveness. If group members with high mutual trust make mistakes, these mistakes might not be discovered due to the reduced mutual control caused by having high mutual trust. This should lead to reduced group effectiveness (cf., Jarvenpaa et al. 2004; Dirks and Ferrin 2001). Due to the fact that efficiency is defined as effectiveness per time, the time saved while performing the task has to be very high in order to obtain good efficiency with low effectiveness. Therefore, it is expected that low effectiveness will lead to poor efficiency (see Fig. 2, left side).

Contrarily, *low mutual trust* should increase mutual control and, therefore, the needed time; that is, it should reduce group efficiency. *Low mutual trust* has already been shown to lead to more relationship conflicts and task conflicts as well as to reduce the time of constructive collaboration (Peterson and Behfar 2003). However, there is a good chance that the mistakes of the collaboration partners will be discovered. As a consequence, higher group effectiveness can be expected (see Fig. 2, right side).

Due to the fact that, compared to face-to-face collaboration, computer-supported collaboration is often accompanied by various difficulties (e.g., Janssen and Bodemer 2013), it is most likely that the group members will make mistakes. Therefore, the following argumentation refers only to collaborations in which mistakes appeared.

In computer-supported environments, the ability for mutual control is often more limited compared to face-to-face settings. Therefore, it is to assume that in computer-supported environments mutual control is very effortful.

One research goal of this study was to investigate the impact of mutual trust in virtual groups on group performance depending on whether the KIA approach was available or not. (Mutual trust is a predictor here.)

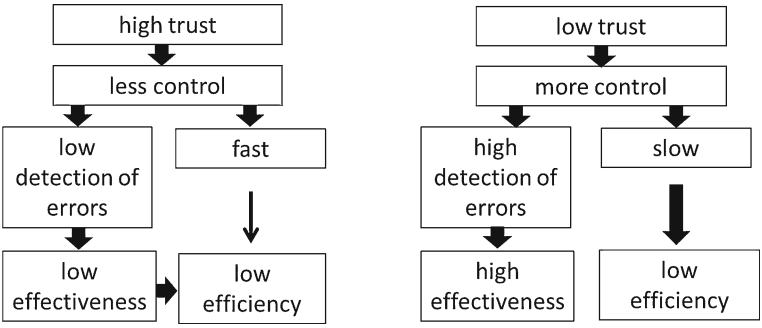

Fig. 2 The impact of high trust (*left side*) and high trust (*right side*) on group effectiveness and group efficiency

The amount of mutual trust also varies depending on prior group experience in a concrete group (Aubert and Kelsey 2003). As a consequence, depending on the amount of collaboration quality in the group, a different amount of trust should develop.

Another research goal of this study was to clarify the question of whether – depending on the availability of the KIA approach – differences in the amount of collaboration quality have an impact on the development of trust after the collaboration. (Mutual trust is the criterion here.)

Experimental study

With regard to these two research goals the following expectations were postulated.

Expectations

Postulated effects of the interaction between initial trust and condition on group performance (trust as predictor) Without being provided with the KIA approach (control condition), it was to be expected that trust will affect group effectiveness: As explained above, if mutual trust is high, it was to be expected that there was low mutual control and, therefore, mistakes would not be detected. This should decrease group effectiveness (cf., Jarvenpaa et al. 2004; Dirks and Ferrin 2001) and – because of its relation to effectiveness – efficiency. However, low trust should lead to mutual control, even if mutual control was effortful in computer-supported settings. This should reduce efficiency, while effectiveness should be increased. (However, due to the mutual control difficulties in virtual groups, it was to be expected that not all mistakes would be detected.).

In addition, it was expected that by direct access to the collaborators' knowledge and information, the availability of the KIA approach (experimental condition) would facilitate mutual control. The ability for easy mutual control can therefore be given also in virtual groups. In prior studies (e.g., Engelmann and Hesse 2010), it was confirmed that the KIA approach is used if it is available. This means that even though the group members were not explicitly instructed to cognitively process the maps depicting their collaborators' knowledge structures and information, when these maps were provided, cognitive processing of the maps did take place. Therefore, there should not be an impact of mutual trust on mutual control; that is, there should be mutual control independent of the amount of mutual trust. Consequently, it was to be expected that the amount of mutual trust would not have an impact on group effectiveness and group efficiency.

Due to the fact that first, the collaborators' work would be checked over and, therefore, their mistakes would be detected, and second, because the process costs of mutual control are low, an effective and efficient group performance was to be expected, compared to groups that collaborate without the KIA approach.

To sum up, we hypothesized – under the assumption of the existence of individual mistakes in virtual groups – the following effects:

Hypothesis 1: Regarding *group effectiveness* as criterion, we expected a significant interaction between initial mutual trust and condition. In more detail, we expected that (1.1) in the experimental condition, initial trust would not have an impact on group effectiveness, while (1.2) in the control condition, high initial trust would reduce effectiveness because of less mutual control and, therefore, less mutual corrections of mistakes.

Hypothesis 2: Regarding *group efficiency* as the criterion, we only expected a main effect for condition in favor of the experimental condition; that is, (2.1) the experimental condition would be more efficient compared to the control condition. We expected (2.2) neither a main effect for trust nor an interaction of trust and condition on group efficiency.

Postulated effects of the interaction between the quality of performance within the group and condition on the development of mutual trust (trust as criterion) The amount of mutual trust varies also, for example, depending on the experiences in a concrete group (Aubert and Kelsey 2003). Therefore, depending on the amount of collaboration quality of the groups, a different amount of trust should be developed.

It was assumed that in the control condition, poor collaboration quality of the group will lead to low mutual trust and high mutual skepticism, respectively. The difficult mutual control in virtual groups should lead to the following: The group members should attribute poor collaboration quality to their collaborators, because they were not able to check the others' work completely. In the experimental condition, however, it was to be expected that the group members check each other's work due to the easy opportunities provided by the KIA approach. Poor collaboration quality of the group should, therefore, not be attributed to the collaborators whose work has been checked, but to external factors such as task difficulties.

Hypothesis 3: We expected a significant interaction between condition and the amount of collaboration quality of the group, having an effect on developed trust and developed mutual skepticism respectively. In more detail, we expected that (3.1) in the experimental condition, the amount of collaboration quality of the group would not have an impact on developing mutual skepticism, while (3.2) in the control condition poor collaboration quality of the group would lead to the development of mutual skepticism regarding the others' abilities.

A summary of all postulated hypotheses can be found in Table 1.

Method

An experimental condition consisting of 20 triads being provided with the KIA approach was compared to a control condition consisting of 20 triads collaborating without this approach.

Participants Participants of the study were 120 students (84 female, 36 male) of a German university from different fields of study with an average age of 23.74 years (SD=3.47). They

Table 1 Summary of hypotheses

Effects on group effectiveness	
1.1	In the experimental condition, initial mutual trust has no impact on group effectiveness.
1.2	In the control condition with increasing initial mutual trust, group effectiveness decreases.
Effects on group efficiency	
2.1	The experimental condition solves the problems more efficiently than the control condition.
2.2.	Trust has no impact on group efficiency.
Effects on mutual skepticism	
3.1	In the experimental condition, the amount of collaboration quality has no impact on the development of mutual skepticism.
3.2	In the control condition with a decreasing amount of collaboration quality, more mutual skepticism develops.

Notes: Experimental condition: with knowledge and information awareness approach; control condition: without it

volunteered to participate for payment. The participants collaborating in groups of three were randomly assigned to a control condition (20 triads) or an experimental condition (20 triads).

The compositions of the groups regarding gender were equal between the conditions; that is, both conditions had the same number of groups with no, one, two, or three women.

The members of a group either did not know each other or hardly knew each other: There was no significant difference between the conditions regarding the degree of acquaintance among the members in a group ($F<1$).

The participants were not balanced with respect to the field of study because the domain material was artificial and, therefore, no advantage could exist for a particular field of study.

Setting and materials The members of a triad were spatially distributed and collaborated through a computer-supported environment. They communicated by using Skype (only audio). The experimental environment consisted of several shared and unshared working windows of CmapTools, a digital concept mapping software developed by the Florida Institute for Human and Machine Cognition (USA).

The study was held in German. Therefore, for this paper, all contents have been translated into English.

The domain refers to rescuing a fictitious type of spruce forest and consisted of 13 concepts, 30 relations between the concepts and 13 pieces of background information (in parts divisible into sub-elements), each linked to a concept. These elements were evenly distributed among the three group members in a way that each member had the same amount of shared and unshared concepts, relations, and background information aspects. The shared elements were shared with either one collaborator or both collaborators.

The following online questionnaires and instructions were used in the study:

An online questionnaire for assessing several control measure items (e.g., experience in working with computers and in groups) and for measuring the amount of initial mutual trust was included. For measuring mutual trust several items taken from Amelang et al. (1984), from Jarvenpaa et al. (1998), as well as from Jarvenpaa et al. (2004) were used that were translated into German and partly adapted to our experimental setting. The 15 control measure items and the 13 items for assessing mutual trust were designed as multiple-choice items with five-point rating scales, ranging from complete agreement to no agreement. Examples of items are: “I can create visualizations by means of a computer” (control measure item) and “In contact with strangers, it is better to be careful until they have provided evidence that one can trust them.”

An online knowledge test was used to measure the knowledge of group members regarding their own and their collaborators' knowledge on particular relations and concepts. It consisted of 24 multiple-choice test items. These items were classified with regard to who possessed the requested knowledge, resulting in four types of items: (1) items asking for *one's own unshared elements*, that is, items measuring knowledge that one alone had in his/her individual map (Item example for Expert A: "Please mark which expert(s) had knowledge about the relation between Topisol and nitrate – Expert A, B, or C?" Only Expert A had this knowledge.), (2) items asking for the *collaborators' unshared elements,* that is, items measuring knowledge that only one of the collaborators had (Item example for Expert A: "Please mark which expert(s) had knowledge about the relation between Oxatrol and potassium – Expert A, B, or C?" Only Expert B had this knowledge.), (3) items asking for *shared elements that one shared with one of the collaborators*, that is, items measuring knowledge that one had together with one of the collaborators (Item example for Expert A: "Please mark which expert(s) had knowledge about the relation between spruce and potassium – Expert A, B, or C?" Only Experts A and B had this knowledge.), and (4) items asking for *shared elements of the collaborators*, that is, items measuring knowledge that only the two collaborators had (Item example for Expert A: "Please mark which expert(s) had knowledge about the relation between spruce and fidget-grub – Expert A, B, or C?" Only experts B and C had this knowledge.). For each item the participants stated whether they were certain that they had answered it correctly (rating scale with three answers possibilities from low, middle, and high certainty).

A second online questionnaire was used to evaluate the study as a whole to assess aspects of collaboration and mutual control, to subjectively rate the quality of the group performance as well as to measure the amount of mutual trust and skepticism after collaboration. For measuring mutual trust and skepticism several items taken from Jarvenpaa et al. (1998) that were translated into German and adapted to our experimental setting as well as our own created items were used. In addition, only in the experimental condition was the usefulness of the KIA approach assessed. Again the items were designed as rating scales with answer categories ranging from one point for no agreement and five points for complete agreement. The questionnaire contained 50 items in the control condition and – due to the additional items – 56 items in the experimental condition.

The group members were provided with a paper-based instruction on how to use CmapTools and with a paper-based instruction to explain all the phases of the study and the tasks to be completed by the group members.

Procedure After informing the participants about the framework of the study and obtaining their signed letter of agreement to take part in the study, the three members of a group were sent to separate rooms each equipped with a desk and a computer. They began the study by individually filling out the online questionnaire for assessing several control measure items and their initial mutual trust. After that, each group member practiced using CmapTools until she or he was familiar with the core functions of creating digital concepts maps. This practicing phase took about 10 to 20 min. In the subsequent phase, the group members were informed that they should imagine that they were three experts who would have to mutually rescue a spruce forest. They were told that in order to rescue this forest they would have to solve two problems, namely, first which pesticide and second which fertilizer they would use. The fertilizer problem could only be solved correctly if the pesticide problem was solved correctly. The groups were told that there was only one solution for each problem. Thus, the problems were well-defined. They were further told they should imagine that in the past they had taken some notes regarding these problem domains and that – based on these notes – they had to create their own concept map visualizing their own knowledge and information. They were given the

notes containing one of three partly different pieces of expert information and had 20 min to create their individual concept map. This was enough time for each group members to finish the individual map. Log files of creating the individual maps were generated (by CmapTools).

After that the groups of the experimental condition were additionally provided with their collaborators' individual concept maps for 5 min. This individual phase was included to assure that the members of the experimental condition looked at their partners' map. In order to control the time in the individual phase, the group members of the control condition had 5 more minutes for viewing their own individual map.

Then the collaborative problem solving phase started, lasting 35 min. In this phase, the groups had to solve the two problems for rescuing the forest. In order to accomplish this, they had to merge their individual conceptual knowledge by jointly creating a single group concept map in a shared working window. The background information aspects were irrelevant to the problem, but this was not known to the group members. The group members could speak with each other by using Skype (only audio). Besides the shared working window, each member of the control condition had access to their own individual concept map that they had created in the individual phase (see Fig. 3 left side).

The members of the experimental condition were – throughout the whole collaboration phase – additionally provided with their collaborators' individual concept maps visualizing their collaborators' conceptual knowledge and background information (see Fig. 3, right side). Due to the fact that the knowledge and information elements were evenly distributed among the three members of a group, there was no information difference between the conditions. The only difference was the visibility of the partners' knowledge and information.

In this collaborative phase, log files of creating the group maps were generated (by CmapTools), and computer screen contents as well as audio conversations were captured (by Camtasia).

Thereafter, a second individual phase with no time limits and no access to the experimental environment started in which the group members first had to fill out an online knowledge test for measuring KIA and second had to complete a questionnaire for evaluating the study and aspects of collaboration and problem-solving as well as for measuring the amount of developed mutual trust and skepticism.

At the end of the study, the participants were thanked, rewarded, and debriefed.

Predictor measures

To answer the hypotheses, besides differing between *control condition* and *experimental condition*, the following measures were used as predictor measures:

The factor "trust in others due to experience" (in the following this will be called *initial trust*) was used to answer Hypotheses 1 and 2.[1] There was no significant difference between the conditions regarding this factor (M_C=0.16; M_E=−0.16; $F(1, 38)$=1.06; MSE=1.00; p=0.31).

To answer Hypotheses 3, the following predictors were used:

The predictor *solution potential of the individual maps* means the amount of domain content in the three individual maps of a triad needed to solve the problems. The more

[1] A factor analysis with Varimax rotation with the 13 trust items included in the questionnaire on control measurements was applied and resulted in these two interpretable factors (cf. Bortz and Schuster 2010): initial skepticism, *Cronbach's* α=0.59; initial trust, *Cronbach's* α=0.78. Since the internal consistency is only acceptable if Cronbach's α is higher than 0.70 (e.g., Nunnally and Bernstein 1994), the factor "initial scepticism" was not included in further analyses.

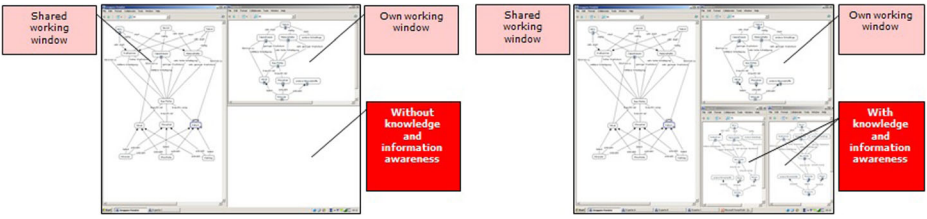

Fig. 3 Computer screen of the control condition (*left side*) and the experimental condition (*right side*)

problem-relevant aspects were in the three maps, the higher their solution potential was. If the three individual maps of a triad contained all correct domain content aspects that were needed to solve both problems, two points were given. If information was missing or wrong, and therefore only one of both problems could be solved, one point was given. If no problem could be solved by means of the three maps, no points were given. The interrater agreement was ICC=0.85 (two-way mixed single measures (cf. Shrout and Fleiss 1979). As assumed, there was no significant difference between the conditions regarding this variable (F<1).

For analyzing the completeness of the group maps that the triads created in the collaborative phase, two dependent measures were assessed: the number of correctly drawn nodes in the group map (called *correct nodes in the group map*), that is, nodes with correct labels (max. 13 attainable points) and the number of correctly drawn relations contained in the group map (called *correct relations in the group map*), which means that the start and end node of the relation as well as the label were correct (max. 30 attainable points). In order to determine these measures, the group maps were compared to an original map representing all correct nodes and relations of the artificial domain material. The groups received one point for each entry of each category (e.g., if the group map of Group 3 contained 12 correctly drawn relations, this group received 12 points for the category "correct relations in the group map"). The interrater agreements were ICC=1 for correct nodes and ICC=0.99 for correct relations (two-way mixed single measures (cf. Shrout and Fleiss 1979).

Criterion measures

Criterion measures regarding group performance: Regarding *group effectiveness* the following measures were differentiated:

Group maps' suitability for problem-solving refers to the amount of domain content in the group map that is needed to solve the problems. The more problem-relevant aspects are in the map, the more it is suited to solve the two problems. In this regard, two dependent measures were differentiated, namely *group maps' suitability for solving the pesticide problem* and *group maps' suitability for solving the fertilizer problem.* If in a group map all correct domain content aspects were available that were needed to solve the pesticide problem, one point was given. If information was missing or wrong, and therefore, the pesticide problem was not solvable by viewing the group map, no points were given. Analogous to this, if the information was provided in the group map for solving the fertilizer problem, one point was given, if information was missing or wrong and as a consequence the fertilizer problem was not solvable by viewing the group map no points were assigned. The interrater agreement was *Cohen's* κ=1 for "group maps' suitability for solving the pesticide problem" and *Cohen's* κ=0.87 for "group maps' suitability for solving the fertilizer problem" both indicating high rater agreement (Cohen 1960).

Regarding the quality of the problem solutions of the groups, we differentiated between two dependent measures, namely *solving the pesticide problem correctly* and *solving the fertilizer*

problem correctly. If a group solved the pesticide problem correctly, one point was given, if the wrong pesticide was chosen, no points were given. Analogous to this, if a group solved the fertilizer problem correctly, one point was assigned, if the wrong fertilizer was chosen, no points could be attained. The interrater agreements were for both measures *Cohen's* $\kappa=1$ indicating perfect interrater agreement (Cohen 1960).

Regarding *group efficiency* the following measures were differentiated:

Because effectiveness was determined as a dichotomy variable in this study (solved vs. not solved), to determined efficiency measures, only those triads were included that solved the pesticide problem and/or the fertilizer problem correctly. Two measures were differentiated: The variable *efficiency of deciding for the correct pesticide solution* refers to the collaboration time needed to decide on the correct pesticide solution. The variable *efficiency of deciding for the correct fertilizer solution* refers to the collaboration time needed to decide on the correct fertilizer solution. The interrater agreement was $ICC=0.96$ for efficiency of deciding on the correct pesticide solution and $ICC=0.96$ for efficiency of deciding on the correct fertilizer solution (two-way mixed single measures, cf. Shrout and Fleiss 1979).

Criterion measures regarding developed mutual trust and developed mutual skepticism after collaboration The factors "trust in the others' ability and motivation" (called *developed trust*) and "skepticism regarding the others" (called *developed skepticism*) were used as dependent measures[2].

For validating purposes, we correlated the predictor factor "initial trust" with the criterion factors "developed trust" and "developed skepticism: Initial trust did neither significantly correlate with developed trust ($r=-0.01$, $p=0.96$), as one might have expected, nor with the other criterion factor ($r=-0.17$, $p=0.29$). The reason for this may be ascribed to the type of items that the particular factor was based on: Initial trust refers to items such as "In most of the groups that I have worked with in the past, the group members trusted each other" or "In the past, I have worked mostly together with trustworthy people" and, therefore, it refers to the amount of general trust in others developed by prior experience, in the sense of a trait. In contrast, the factor, developed trust, was mainly based on items such as "The others [in the sense of the collaboration partners in this current study] aimed to successfully contribute to the problem solving" and "The others had knowledge that contributed to solving the problems" and, therefore, refers to mutual trust in the collaborators' performance in the sense of their motivation and their ability. Trust is here a state.

Results

The experimental condition in which the group members were provided with a KIA approach was compared with the control condition in which the group members collaborated without

[2] The questionnaire after the collaboration phase contained 50 items (that were identical between the conditions), that is, three factor analyses were necessary to comply with the rules for conducting factor analyses (cf. Bortz and Schuster 2010). Factor Analysis 1, including 17 items on trust, resulted in two interpretable factors: Developed trust, *Cronbach's* $\alpha=0.73$; developed skepticism, *Cronbach's* $\alpha=0.78$. Factor Analysis 2, including 19 items on mutual control, coordination, communication, and subjective evaluation of the group outcomes, resulted in one interpretable factor: Developed suspiciousness, *Cronbach's* $\alpha=0.46$. Factor Analysis 3, including 14 items on study evaluation, group map creation, and collaboration, resulted in one interpretable factor: Cognitive effort, *Cronbach's* $\alpha=0.50$. Because of their low *Cronbach's* α values, the factors "developed suspiciousness" and "cognitive effort" were not included in further analyses.

this approach. All analyses presented here were based on the group level because most of the dependent variables were variables on group level (e.g., the group answers, the group maps) and individuals in a group are not independent of each other. Following Cress (2008), the analyses have to be based on aggregated data of individuals, for example, in form of means, if groups are the units of the analyses. Therefore, variables measured on the individual level were aggregated; that is, group means were calculated. This also assures having the same analysis level as the group variables.

The inclusion of a covariate was not necessary.[3]

The reasons for using moderator analyses and the explanation of the procedure can be found in the Appendix "Analytical Procedures".

Manipulation check

It was analyzed whether our KIA approach fostered the acquisition of knowledge and information awareness.

The analysis of the answers to the knowledge test resulted in a significant higher KIA value for the experimental condition compared to the control condition (M_C=18.77, M_E=22.87; $F(1, 38)$=7.41; MSE=22.66; p=0.01; η_p^2= 0.16). This value was calculated as the sum of item Categories 2 and 4 each weighted by the correctness certainty (see section "Setting and materials") because only these categories merely referred to the collaborators' knowledge.

This is accordant with the results of prior studies (e.g., Engelmann et al. 2010; Engelmann and Hesse 2010).

In the questionnaire after the collaboration, the members of the experimental condition mostly stated that they used or viewed the windows with the collaborators' maps only sometimes (M=3.29, SD=0.52). However, they also maintained that the windows with the collaborators' maps were helpful (M=3.92, SD=0.59), indispensable (M=3.14, SD=0.77), helped to recognize differences and similarities between their own and the collaborators' maps (M=3.88, SD=0.81), helped to acquire a clear mental model of the collaborators' knowledge (M=3.63, SD=0.80), and to avoid misunderstandings (M=3.47, SD=0.67).

It is interesting to note that these descriptive values are lower compared to prior studies that used the same domain and tasks (e.g., Engelmann and Hesse 2010). However, less use and lower evaluated helpfulness did not affect the acquisition of knowledge and information awareness.

Results on postulated effects of the interaction between initial trust and condition on group performance

An overview of the results of all corresponding moderator analyses can be found in Table 2.

Group effectiveness as criterion variable The regression analyses with effectiveness measures as criterion variable as well as condition, initial trust, and their interaction as predictor variables led to the following results:

[3] A factor analysis with Varimax rotation with the 15 control measure items resulted in six factors with eigenvalues higher than 1. According to Bortz and Schuster (2010), in a Varimax-rotated factor structure, only those factors can be interpreted that have at least four items with a loading>0.60 or at least ten items with a loading>0.40. This criterion was met only by the factor "computer experience". However, an univariate ANOVA did not result in a significant difference between the two conditions (F<1).

Table 2 The results of the moderator analyses of initial trust and condition on group performance, including regression analyses and simple slope analyses

						Model properties		
Criterion variable	Predictor variables	*b*	SE	β	*p*	Adj. R^2	F(df)	*p*
Solution potential of the pesticide problem in the group map	Initial trust	0.00	0.09	0.01	0.96	[0.005]	[0.91(2, 37)]	[0.41]
	Condition	−0.03	0.08	−0.05	0.75			
	Initial trust *x* condition	0.21	0.09	0.42	0.03	0.102	2.48(3,36)	0.08
	Simple slope CC	0.20	0.09	−0.41	0.03			
	Simple slope EC	0.21	0.16	0.43	0.18			
Solution of the pesticide problem	Initial trust	0.04	0.09	0.09	0.62	[−0.018]	[0.66(2, 37)]	[0.52]
	Condition	−0.02	0.07	−0.04	0.78			
	Initial trust *x* condition	0.25	0.09	0.50	< 0.01	0.153	3.35(3, 36)	0.03
	Simple slope CC	−0.21	0.08	−0.42	0.02			
	Simple slope EC	0.29	0.15	0.60	0.06			
Efficiency of deciding for the correct pesticide solution	Initial trust	−127.96	117.38	−0.23	0.29			
	Condition	−193.78	93.74	−0.40	0.05			
	Initial trust *x* condition	−180.10	117.38	−0.32	0.14	0.16	2.50(3, 21)	0.09
Efficiency of deciding for the correct fertilizer solution	Initial trust	33.07	78.99	0.09	0.68			
	Condition	−166.27	63.20	−0.50	0.02			
	Initial trust *x* condition	−16.43	78.99	−0.05	0.84	0.15	2.52(3, 23)	0.08

Notes: Values in brackets represent the model properties before the inclusion of the interaction. The predictor variable "Initial Trust" was z-standardized

Simple Slope CC=Simple slope analysis for the control condition

Simple Slope EC=Simple slope analysis for the experimental condition

The regression analysis with *solution potential of the pesticide problem in the group map* as the criterion variable revealed no significant conditional effect for initial trust or for the belongingness to a particular condition. Though, a significant interaction between condition and initial trust appeared: Simple slope analyses indicated as hypothesized that higher initial trust significantly reduced the solution potential of the pesticide problem in the group maps of the control condition but did not significantly affect the solution potential of the pesticide problem in the group maps of the experimental condition.

In line with these results, the regression analysis with the *solution of the pesticide problem* as the criterion variable also did not reveal significant conditional effects, however, a significant interaction between condition and initial trust. Simple slope analyses indicated, as expected, that higher initial trust significantly impaired the solution of the pesticide problem of the control condition but did not significantly affect the solution of the pesticide problem of the experimental condition.

Please note that regarding the measures *group maps' suitability for solving the fertilizer problem* as well as *solution of the fertilizer problem* as criterion variables, no significant effects resulted. Therefore, these results are not reported.

Group efficiency as criterion variable The regression analyses with efficiency measures as the criterion variable as well as condition, initial trust, and their interaction as predictor variables led to the following results:

According to our hypothesis, the regression analysis with *efficiency of deciding for the correct pesticide solution* as the criterion variable revealed a significant conditional effect for the belongingness to a particular condition. The experimental groups needed less time for finding the correct pesticide solution compared to the control groups (M_C=19:56, SD_C=7:21; M_E=13:15, SD_E=7:55). As expected, we neither found a significant conditional effect for initial trust, nor did a significant interaction between condition and initial trust appear.

In line with this result, the regression analysis with *efficiency of deciding for the correct fertilizer solution* as criterion variable also revealed, as expected, a significant conditional effect for the belongingness to a particular condition. The experimental groups needed less time for finding the correct fertilizer solution compared to the control groups (M_C=22:40, SD_C=4:42; M_E=17:16, SD_E=5:23). Again, as expected we neither found a significant conditional effect for initial trust, nor did a significant interaction between condition and initial trust appear.

Results on the postulated effects of the interaction between quality of performance within the group and condition on the development of mutual trust

Because it was expected that the amount of trust also depends on situational factors, the impact of collaboration quality of the group, depending on the condition, on the developed trust, and developed skepticism, respectively, was analyzed. An overview of the results of all corresponding moderator analyses can be found in Table 3.

The regression analysis with *developed skepticism* as the criterion variable revealed a marginally conditional effect for the solution potential of the individual maps, but not for the belongingness to a particular condition. With an increasing solution potential of the individual maps, less skepticism was developed. As hypothesized, a significant interaction between condition and the solution potential of the individual maps emerged. Simple slope analyses indicated that lower solution potential of the individual maps significantly increased the developed skepticism in the control condition, but did not significantly affect the developed skepticism in the experimental condition.

Table 3 The results of the moderator analyses of collaboration quality and condition on the development of mutual skepticism, including regression analyses and simple slope analyses

						Model properties		
Criterion variable	Predictor variables	*b*	SE	β	*p*	Adj. R^2	F(df)	*p*
Developed skepticism	Solution potential of the individual maps	−0.26	0.15	−0.26	0.09	[0.007]	[1.14(2, 37)]	[0.33]
	Condition	0.02	0.15	0.36	0.92			
	Solution potential of the individual maps *x* condition	0.36	0.15	0.36	0.02	0.12	2.7(3, 36)	0.06
	Simple slope CC	−0.62	0.22	−0.62	< 0.01			
	Simple slope EC	0.10	0.21	0.10	0.65			

Notes: Values in brackets represent the model properties before the inclusion of the interaction. The predictor variable "Solution Potential of the Individual Maps" was z-standardized

Simple Slope CC=Simple slope analysis for the control condition

Simple Slope EC=Simple slope analysis for the experimental condition

Please note that the corresponding regression analysis with *developed skepticism* as the criterion variable and condition, the *number of correct relations* and their interaction as predictors led to the same result pattern. However, this analysis did not meet the necessary requirements; that is, the assumptions of the global test statistics were not satisfied. Therefore, this analysis was not reported here. In addition, regarding the measure *correct nodes in the group map*, there was no corresponding significant interaction. Regarding the measures with *developed trust* as the criterion variable, no expected interactions were found. Therefore, these results were not reported here.

An explorative case study

In order to corroborate the expected relations between the amount of mutual initial trust and mutual control as a function of having access to the KIA approach, we conducted a case study: For a qualitative analysis within each of the following four categories we randomly selected a triad: a control group with high initial trust, that is with a trust level above the median (we randomly selected group CC 7), a control group with low initial trust, that is a trust level below the median (we randomly selected group CC 2), an experimental condition with high initial trust (we randomly selected group EC 21) and an experimental condition with low initial trust (we randomly selected group EC 22). Following Fig. 2 we postulated that in the control condition, high initial trust will lead to low effectiveness, because of lower mutual control and thus a low detection rate of errors. The transcripted Camtasia recording of CC 7 seems to confirm that there is hardly any mutual control in such groups even if the situation requires it. For example at time code 5:31 f. (see Table 4, CC 7): A question arose by expert C, expert B wanted to answer it, but C interrupted him to give him drawing suggestions. B, however, had yet another suggestion. Important here is expert C's reaction saying "if you say that, then one gets it." He did not further try to clarify the situation. Instead he relied on the other expert.

In contrast to such control groups with high initial trust, it was postulated that control groups with low initial trust would achieve high effectiveness, because checking each other results in a high detection rate of errors. The excerpt of CC 2's recording seems to support this idea (see Table 4, CC 2): Very often the group members instructed their partners to check their

Table 4 Excerpts of the Camtasia files of two control and two experimental groups having either low or high initial trust

Control Condition with high initial trust: CC 7	
Time code (in min.)	Dialog (overall 32:27 min.)
05:22	Expert B: "Wait. The RP2, it's not right like that, is it?"
05:24	Expert C: "I think, it was just in the way"[…]
05:31	Expert C: "What is this Herm+? Does it generate rank spiders during decomposition?"
05:35	Expert B: "No, just combined with the decomposing rank spider it generates phosphate. I don't know how I should …"
05:43	Expert C: "Ah, o.k., you can make another arrow there to here"
05:46	Expert B: "Or I move the Herm"
05:48	**Expert C: "Or like that, but yes, o.k., if you say that, then one gets it"**
Control Condition with low initial trust: CC 2	
Time code (in min.)	Dialog (overall 35:27 min.)
21:31	Expert C: "By the way, potassium is not produced, when the pests die. It's nitrate that is being produced when the pests die, isn't it?"
21:38	Expert A: "No, potassium …wait… potassium yes. Potassium forms, yes. Nitrate, too, definitely, of course, but the info is only potassium."
21:52	Expert C: "Damn. Am I stupid or what? I don't think I really get it. O.k. never mind. "
22:04	Expert A: "In mine its presented as relation 8. Perhaps, it is also in yours… is there nitrate in yours, or what?"
22:11	Expert A: "N-yes"
22:15	**Expert C: "It's written in your word document that they produce nitrate? During the decomposition process?"**
22:20	Expert B: "Wait, I can't find it right now"
23:05	Expert C: "Is it written in yours that dead bugs produce phosphate?"
23:08	Expert B: "I've got to take a look. […] No, I think, this is not written in mine."
23:20	**Expert C: "Isn't it written in your word document under point 8?"**
23:23	**Expert A: "Under pests?"**
23:24	Expert B: "Oh, wait! Sorry, I've looked in the wrong place"
27:04	**Expert A: "Has anyone read the background information in detail?"**
27:08	Expert C: "No, but what do you mean by background information?"
27:10	Expert A: "Well, what is written next to it, because … wait… ah well, o.k., there is actually nothing interesting there."
28:30	Expert B: "Well this Herm+and how it is related to the material bug, I've got no clue. It was not written in mine, I believe."
28:31	**Expert A: "It is definitely written in yours. There is a connection depicted for all others, for sure."**
Experimental Condition with high initial trust: EC 21	
Time code (in min.)	Dialog (overall 21:58 min.)
00:21	**Expert C: "I have noticed that some things mutually exclude each other, for example the pesticides, uhm, the fertilizers. […] Expert A, you have this Topisol, it extracts nitrate** […]
00:38	Expert A: "I think all extract, whatever fertilizer we use. It always supplies one thing and extracts all the other things."

Table 4 (continued)

01:04	**Expert A:** "Potassium definitely does, if we decide on RP2 for control, potassium would be produced through that control, **and I read in B's,** that if one uses this Herm+thing, then it produces phosphate, right?"
01:28	Expert B: "Yes, exactly."
Experimental Condition with low initial trust: EC 22	
Time code (in min.)	Dialog (overall 23:55 min.)
05:43	**Expert B: "What's that info added in Expert A's? Next to that RP2? There is something attached. May I read it?"**
05:50	A: "Wait, I don't know."
15:55	Expert C: "Then it has a moderate effect against the flunder caterpillar?"
15:58	Expert B: "Oh, it also has an effect?"
16:01	**Expert C: "Yes, that is what Expert A has written here.** It says: 'the effect against other pests is moderate.'"

individual information in their individual map or their corresponding word document (see e.g., time codes 22:15, 23:20, 27:04 or 28:31).

We expected that members of the experimental condition would control each other independently of the amount of initial trust. The excerpts of EC 21's and EC 22's confirmed this idea (see Table 4, EC 21 and EC 22). There seems to be no difference between these two groups. Independently of the amount of initial trust group members control each other, but not like in CC 2. In contrast to CC 2 in which partners instructed each other to check their individual files, partners in both, EC 21 with high trust and EC 22 with low trust, use the KIA approach to take a look at their partners' maps. The comparison of the statements on time codes 00:21 and 1:04 in EC 21 and the time codes 05:43 and 16:01 in EC 22 indicate that the group members used their access to the partners' maps for mutual control, independently of the amount of initial trust.

Discussion

In this paper, we investigated two research questions. The first research question focused on the impact of mutual trust in virtual groups on group performance depending on whether the KIA approach is available or not. With regard to group effectiveness, we expected a significant interaction between condition and initial trust on group effectiveness in a way that increasing trust will decrease effectiveness in the control condition, while in the experimental condition trust will not have an effect on group effectiveness (Hypotheses 1.1 and 1.2).

To test these hypotheses, along with the others, 120 participants were investigated, grouped in 20 triads that were provided with the KIA approach and 20 triads collaborating without it.

The analyses confirmed our hypotheses: In the experimental condition, mutual trust did not significantly affect group effectiveness; however, in the control condition with increasing mutual trust, group effectiveness, measured as both solution potential of the pesticide problem in the group map and solution of the pesticide problem, significantly decreased.

These results provide evidence that the negative impact of mutual trust can be counteracted successfully by the availability of the KIA approach. We explained this result with the fostering of mutual control when the KIA approach is available. Our explorative case study seems to confirm this explanation: As expected, in the audio transcript of a control group with high initial trust there was hardly any mutual control, even if the situation required it. In contrast, the transcript of a control group with low initial trust showed that the members often instructed their collaboration partners to check their individual information in their map or in

their word document (cf. Fig. 2). However, as expected, the amount of initial trust seems to have no effect on the amount of mutual control in the experimental groups. The transcripts of an experimental group with high mutual trust and of an experimental group with low mutual trust seemed not to differ regarding the amount of mutual control. Independently of the amount of initial trust the participants controlled each other. Yet, they differed from the control group with low initial trust. The experimental group members used the access to their partners' maps (i.e., the KIA approach) for mutual control. To sum up, these case study results supported the assumptions postulated for the control condition (Fig. 2) and the experimental condition.

Another explanation for the significant interaction between initial trust and condition on group effectiveness might be a stronger structuring of the situation in the experimental condition, caused by the KIA approach, in which trust did not have an impact (cf. Dirks and Ferrin 2001; Jarvenpaa et al. 2004). However, further studies are needed to explain the causes of the present findings in more detail.

It is interesting to note that the present effects were only found with the pesticide problem, but not with the fertilizer problem. A reason for this could be that the fertilizer problem could only be solved correctly if the pesticide problem was solved correctly, that is, solving the fertilizer problem depended more on solving the pesticide problem than on other reasons. Another reason could be the different task structures of the two problems. The pesticide problem requires combining some variables with other variables, whereas solving the fertilizer problem mainly depends on finding the correct solution of the pesticide problem and on considering the relevant variables of the pesticide problem for the fertilizer problem. In this way, solving the pesticide problem is more complex than solving the fertilizer problem. This would mean that the KIA approach only reduces the negative impact of initial trust on solving complex problems. However, this has to be corroborated by further studies.

One should note that due to its low *Cronbach's* α value the factor "initial skepticism" could not be used in further analyses. Initial trust was based on items such as "In most of the groups that I have worked with in the past, the group members trusted each other" or "In the past, I have worked mostly together with trustworthy people". Therefore, it refers to the amount of general trust in others developed by prior experience. Initial skepticism was based mainly on items such as "One should be very careful if working together with strangers" or "In current times, with so much competition, you should be on the alert or someone will probably take advantage of you" and, therefore, refers mainly to a generalized skepticism about others, based more on a general attitude. Whether our findings for initial trust could also hold up for initial skepticism has to be investigated with a more reliable initial skepticism measure.

With regard to group efficiency, we expected for groups in the control condition with high trust also low efficiency because efficiency is dependent on effectiveness. For groups in the control condition with low trust, we also expected low efficiency due to much mutual control that takes time. For the experimental condition, we expected, independent of the amount of trust, high group efficiency due to the low process costs for checking the others' work (Hypotheses 2.1 and 2.2).

This hypothesized main effect was found: In line with prior study results (e.g., Engelmann and Hesse 2010), the experimental groups solved both of the problems sooner compared to the control groups. As expected, neither a main effect for trust, nor an interaction between trust and condition, on group efficiency were observed.

Together with the findings on group effectiveness, this result demonstrated that mutual trust may have an effect on group effectiveness, but not on group efficiency. This is accordant with Kanawattanachai and Yoo (2002) and Jarvenpaa et al. (2004). Therefore, this paper also contributes to solving the conflicting findings in literature regarding the effects of trust.

Our hypotheses were derived, among others, from the assumptions regarding mutual control. However, in this study, we did not analyze mutual control. Future analyses could be

based on the recorded discussions. However, in order to analyze mutual control in a better way, eye tracking is needed. Eye tracking results could contribute to further clarifying the postulated relations.

While in the first research question, trust was investigated as predictor, in the second research question, it acted as criterion. The second research question addressed whether – depending on the availability of the KIA approach – differences in the amount of collaboration quality have an impact on the development of trust after the collaboration.

We hypothesized that in the control condition, poor collaboration quality of the group will lead to low mutual trust and high mutual skepticism, respectively, because a computer supported environment does not normally allow for easy mutual control; that is, the work of others cannot be checked easily; therefore, poor collaboration quality is more likely to be attributed to the collaborators. In contrast, it was hypothesized that in the experimental condition, poor collaboration quality was not attributed to the collaborators, whose work has been checked, but to external factors such as task difficulties and therefore would not affect the development of mutual trust or mutual skepticism, respectively. To sum up, we expected a significant interaction between condition and the collaboration quality, the latter measured as a solution potential of the individual maps and the completeness of the group map, on the amount of developed trust and developed skepticism, respectively (Hypotheses 3.1 and 3.2).

The analyses for answering the second research question led to the hypothesized results: In the control condition, with decreasing solution potential of the individual maps, the developed mutual skepticism regarding the collaborators' performance increased. In the experimental condition, the collaboration quality of the group had no impact on the development of mutual skepticism.

It is interesting to note that regarding the second research question, the findings in accord with our hypothesis were only found with the factor developed skepticism and not with the factor developed trust. This may be due to a qualitative difference between the two factors. The factor, developed skepticism, is based on items such as "With another group, the problem solving phase would have been more successful" and "I often had the impression that the other experts did not understand their information correctly". This refers mainly to dissatisfaction with the other group members' abilities. In contrast, the factor developed trust was mainly based on the following items: "The others aimed to successfully contribute to the problem solving" and "The others had knowledge that contributed to solving the problems". It refers to mutual trust in the collaborators' performance in the sense of their motivation and their ability.

It also should be noted that regarding the second research question, we failed to find the postulated interaction with variables of the completeness of the group maps. One reason was, as described, that the needed requirements for conducting the analyses were not met.

There are some limitations of the study that have to be considered: The group members were not experts with regard to the knowledge needed for solving the problems in the study. However, each group member was provided with content material, and in an individual phase, they had time to become familiar with it. In real situations, group members often have to acquire new knowledge. For example, especially in collaborative learning settings, learners often divide learning material in such a way that each learner only learns a part of the whole learning material, and then, in a subsequent collaborative situation, they teach each other in order for everyone to learn the not yet learned contents. In an empirical study by Lechner and Engelmann (not yet published), the knowledge and information approach was applied in a school context in which one class was taught one topic in biology and another class was taught a different topic also in biology. In a subsequent collaboration phase, one student of one domain collaborated computer-supported with another student of the other domain, in order to teach each other the respective contents of each domain. The aim was to enable the students to

collaboratively solve problems that required the knowledge of the contents of both domains. As in our study, both dyadic learners did not have prior knowledge of the domain they had to learn. However, in this study by Lechner and Engelmann, the effect of trust was not investigated. The impact of trust in real application fields on group performances still needs to be investigated.

It should be noted further that the domain material was artificial due to experimental reasons (e.g., excluding the impact of prior knowledge). Nevertheless, as the questionnaire completed after the collaboration phase has shown, the participants in both conditions stated that they had enjoyed participating in this study (Mc=4.62, SD_C=0.35; M_E=4.52, SD_E=0.44). In prior studies, we investigated the impact of the KIA approach on group performances also by using non-artificial domains. Along with the mentioned study by Lechner and Engelmann that used content from the biology curriculum in school, in the study by Schreiber and Engelmann (2010), the group members had to solve a criminal case; however, this study also did not focus on the factor trust.

In our study, the group members did not know each other, but each individual had a certain amount of general trust in others, in the sense of a trait (not a state). In the literature (e.g., Colquitt et al. 2007), this type of trust is also called *trust propensity*. Our study has shown that this type of trust has an impact on group performances, namely, a negative impact in the case of too much trust. Therefore, trust must be considered to be an impact factor if groups have to collaborate and solve problems collaboratively.

In several studies, we varied the task structure and always found a positive impact of the KIA approach on group performances. We varied the domain and the task (for example, in the study by Schreiber and Engelmann 2010, that used a criminal case task), the setting (for example, in the school study conducted by Lechner & Engelmann, not yet published), and the separation of individual and collaborative phases (for example, in the study by Engelmann and Kolodziej 2012). In the study by Engelmann and Kolodziej (2012), it was the decision of the group members whether they wanted to create an individual map visualizing their own knowledge and information or not. We could show that group members in the experimental condition that created their individual maps benefitted in the collaboration phase compared to the groups that directly started to solve the problems collaboratively. Groups in the control condition, that is, groups without access to their partners' maps did not benefit if the members created individual maps. In these earlier studies, the factor trust was, however, not investigated. Yet these studies have been able to show that the effect of KIA on group performances is relatively robust and independent of the task structure. Therefore, it can be assumed that the KIA approach will moderate the effect of trust on group performance also when the task structures are varied.

With regard to the robustness of measures used in the study, we would like to add the following: Both trust as predictor as well as trust as criterion were measured by self-ratings. Self-ratings are subjective and can, therefore, differ among individuals. However, the items used to measure trust were items from established trust scales in the literature. Objective measures of trust are difficult to construct and, to our knowledge, not yet possible. Perhaps it can only be measured indirectly, for example, by assessing mutual control. Whether it will be possible in the future to measure trust neurophysically is still an open question. A lot of research is needed to find objective measures of trust, and for this reason, we used the established method for assessing trust. With regard to all of the other measures, we calculated interrater agreement, which was without exception high. Thus, a suitable robustness regarding the measures used can be inferred.

With regard to the robustness of the results reported in the current study, we would like to point to the fact that we only reported results of analyses that met the statistical requirements. Therefore, robustness of results is ensured.

With regard to the robustness of interpretations, we would like to point out that we have only interpreted our significant results. Additionally, we would like to add that the positive impact of the KIA approach to group performance has been proven in several studies, whereas with regard to the effect of trust on group performance conflicting findings can be found in the literature. We argued that the reason for the different findings regarding the impact of trust is that the variable "errors made by the individuals" has been neglected. This assumption needs to be validated in further studies, especially in settings with increased ecological validity. In addition, to our knowledge, this study was the first that combined research on trust and research on knowledge awareness. Thus, the findings of our study need to be validated by further studies.

Implications

This study has demonstrated that even in group situations in which the group members do not know each other, general trust in others (as a personal trait) can have a negative impact on group performance. This negative impact can be easily solved by providing external representations of the collaboration partners' knowledge structures and the information underlying these structures. Collaborating with unknown others in ad hoc created groups is becoming increasingly important due to the complexity of today's problems that require the different expertise of several individuals. For collaborating groups, we recommend the externalization of each member's task-relevant knowledge and information to motivate the partners to check over each other's external representations, especially if they have high mutual trust. This leads to the detection of mistakes and consequently to better group effectiveness. In addition, having the possibility to check each other's work in this way improves group efficiency.

Hindering the development of mutual skepticism in virtual groups is also highly relevant, especially if groups need to continue to work together. As our study has shown, the KIA approach can prevent this development.

To sum up, this study demonstrated that the availability of the KIA approach overrides the negative impact of too much mutual trust and prevents the development of mutual skepticism. Additionally, this study further contributes to clarify the impact of trust on group effectiveness and group efficiency in computer-supported collaborative situations depending on different situational factors such as being provided with a KIA approach or not.

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Appendix: Analytical procedures

Due to the fact that we were interested in interaction effects between condition and variables of trust, as well as between condition and variables of collaboration quality, regression analyses were conducted. More concretely, moderator analyses were conducted following Aiken and West (1991). The necessary requirements for conducting regression analyses were tested in each time, that is, for each analysis the global test statistic was calculated: The global test statistic as a function of the model residuals "is formed from four asymptotically independent statistics, each with the potential to detect a particular violation" (Peña and Slate 2006, p. 353). These independent statistics are linearity, homoscedasticity, uncorrelatedness, and normality. In this paper, only those analyses are reported that met the global test statistic.

For condition as a categorical moderator variable, unweighted effects coding was used (control condition=−1, experimental condition=+1) because then, the regression coefficients represent the difference between each condition's mean and the unweighted mean of both conditions (Cohen et al. 2002). Z-standardization was applied on all other predictors because they were continuous variables. Like centering, z-standardization eliminates the problems of multicollinearity between the categorical moderator variable and the specific continuous predictor variable. In addition to this, it simplifies the comparison of significant moderator effects on different criterion variables and eases their plotting (Aiken and West 1991; Cohen et al. 2002; Frazier et al. 2004).

To calculate the moderator analyses according to Aiken and West (1991), a first series of regression analyses was calculated with only the moderator and another predictor as predictor variables and an outcome measure as the criterion variable. This first series of regression analyses was needed to obtain the change in adjusted R^2 in a second series of regression analyses with the same variables and also – by multiplying the moderator with the other z-standardized predictor – the interaction term for the additional explained variance of the interaction. To test the significance of the simple slopes for each level of the categorical moderator variable, two additional regression analyses were conducted (Aiken and West 1991; Frazier et al. 2004): To test the significance of the simple slope for the control condition, a dummy coding of control condition=0 and experimental condition=1 was applied. For the significance of the simple slope for the experimental condition, a dummy coding of control condition=1 and experimental condition=0 was applied. Regression analyses were calculated with one of these newly coded moderators, another predictor, as well as their interaction term as predictor variables, and an outcome measure as the criterion variable.

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Fostering group norm development and orientation while creating awareness contents for improving net-based collaborative problem solving

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ABSTRACT

Empirical studies have demonstrated that being aware of the knowledge structures and of the underlying information of other group members improves computer-supported collaborative problem solving. While such studies used pre-made individual concept maps as awareness tools, empirical studies that used individual concept maps created by the group members themselves have not shown an advantage for group performance. An assumed reason is that individual members' concept maps differ too much structurally so that using them would need a lot of effort. This experimental study compares 20 triads whose members can observe the map creation process of the other members in their group with 20 triads without this possibility. The results demonstrated that access to the map creation process of the other group members while building one's own concept map led to a group norm of how to create such a map. As a result, group members created more structurally similar maps, which led, as in prior studies with pre-made maps, to improved group performance.

1. Collaboration: benefits and challenges

In an increasingly globalized world, solutions to problems often require the collaborative effort of experts who are separated by great distances, cultural boundaries, and time zones. Physical presence of each member of a collaborating collective is often difficult to achieve. In order to solve ad hoc problems, experts from various parts of the globe can, however, utilize communication technologies, especially the various possibilities for interaction afforded by contemporary personal computers. Yet, even though modern technology facilitates instant communication across the globe, collaborating groups using the technology face a number of problems. These problems can be germane to the virtual setting within which interaction between group members takes place, or arise from the potentially volatile nature of the expert group whose members might not have worked together before nor anticipate interactions beyond the task at hand (cf. Bromme, Hesse, & Spada, 2005).

1.1. Problems faced by transiently collaborating groups

Even though telecommunication in general and computer mediated communication (CMC) in particular is constantly becoming more and more sophisticated, it is still not possible to convey verbal messages, gestures, or facial expressions at a level that would be comparable to face-to-face interaction (Buder, 2011; Carroll, Neale, Isenhour, Rosson, & McCrickard, 2003; Janssen & Bodemer, 2013). Hence, compared to face-to-face interaction, CMC has been reported to be less satisfying and more confusing (Thompson & Coovert, 2003). It also seems to generally increase the time and reduce the effectiveness with which groups can accomplish tasks (Baltes, Dickson, Sherman, Bauer, & LaGanke, 2002). However, given the fast paced strides in communication technologies, the challenges that technological limitations pose for CMC are likely to diminish with time.

A more persistent problem for computer mediated collaborative efforts is therefore more likely to be the interpersonal dynamics inherent to interactions of transiently collaborating groups. For example, various lines of research indicate that groups are not very effective at processing information that is not held by all, or at least the majority of group members. Thus according to the information sampling model (Stasser & Titus, 1987; Stasser & Titus, 2003), the more members of a group are privy to a piece of information, the more likely this piece of information will be discussed. In a study

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that manipulated the amount of information given to participants and the portion of that information that was shared among the group members, it was found that if the information load was high or if a substantial bulk of information was available to each group member, unshared information tended to be neglected and forgotten (Stasser & Titus, 1987). The shared information was also found to bias the judgments of the group. For example, in a study in which participant groups had to judge the performance of a student based on several shared and unshared pieces of information, judgments were swayed by information that was held by the majority of the group members (Gigone & Hastie, 1993).

Intuitively, it seems that these problems for CMC based collaboration could be ameliorated by keeping the information load low and making sure that the information which collaborators bring to the discussion is as diverse as possible. However, while such an approach indeed tends to promote the possibly critical exchange of unshared information (Stasser & Titus, 1987), it bears its own disadvantages. Usually, the very purpose of collaboration is to address a problem too complex to be solved by any individual member of the collaborating collective. High information load is thus inherent to most collaborative tasks. Moreover, the less information that collaborators share a priori, the less likely it is that they will find a common ground, a shared knowledge base that they can build their interaction upon and communicate effectively (Clark & Brennan, 1991).

1.2. Transiently collaborating groups and transactive memory

Groups collaborating over a time can eventually avoid some of the pitfalls of having unshared information by developing a transactive memory system (Wegner, 1986), that is, a cognitive map that all group members have about who in the group holds what information. Yet time is needed for group members to gain an understanding of the knowledge structures of each member. This time is often unavailable to virtual groups collaborating via computers.

Absence of a transactive memory system can, in and of itself, impact the collaborative efforts. Without knowledge about a communication partner's knowledge, people tend to infer others' knowledge based on their own knowledge (Nickerson, 1999). The frequent inaccuracy of such inferences, for example over- or underestimations of the partner's knowledge level, can lead to miscommunication. This issue is particularly poignant in contemporary CMC in which the ability to notice a communication error and to compensate for it is constrained by the relative lack of communication cues such as visible gestures and facial expressions (cf. Carroll et al., 2003).

A promising approach is to make all task relevant information and knowledge structures of the group members available to each other from the outset. This avoids the challenges to communication which arise from a lack of a mutual knowledge base (e.g. Clark & Brennan, 1991), from the communication biases inherent to group members sharing only a portion of the group's knowledge (e.g. Nickerson, 1999; Stasser & Titus, 1987), and compensates for a potential lack of time to establish a transactive memory system (Wegner, 1986). While this might not be possible in face-to-face interactions, a boon of CMC is that it affords ways for group members to be instantly aware of the relevant knowledge of a collaboration partner. An exemplary way is the content-based knowledge awareness approach[4] (CoKA; e.g. Engelmann et al., 2009; Engelmann et al., 2010). Within this approach, group members are provided with visual representations of each other's knowledge and information structures. With such a visual representation at hand, collaborators are able to appreciate from the outset the distribution of information within the group, effectively gaining a form of transactive memory system (Schreiber & Engelmann, 2010). Simultaneously, visualization of the partner's knowledge arguably provides collaborators with a common ground upon which to base their discussion.

1.3. The CoKA approach

CoKA places itself within the broader context of group awareness research, that is, research into how providing collaboration partners with information about each other improves their joint effort (Engelmann et al., 2009; Gross, Stary, & Totter, 2005). Yet CoKA stands out in several respects. First, in contrast to group awareness approaches aiming to promote social awareness, an awareness of who is available for interaction, or action awareness, an awareness of who is doing what at a given time (Carroll et al., 2003), CoKA does not aim to introduce features into CMC that would make it more similar to face-to-face communication. Instead, the CoKA approach directly targets the problems inherent to transient group interactions, computer mediated or otherwise. There are other approaches with a similar goal: context based knowledge awareness approaches providing partners with general cues about each other's knowledge levels (e.g. Dehler-Zufferey, Bodemer, Buder, & Hesse, 2011) and hybrid context/content based knowledge awareness approaches whereby partners are given access to each other's interim results and solutions on a task (e.g. Bodemer, 2011). CoKA sets itself apart from these, however, by aiming to provide partners with each other's knowledge and information content from the outset.

A frequently used tool to foster CoKA has been digital concept maps (cf. Engelmann & Hesse, 2010). Concept maps are graphical tools that have been developed to represent hierarchical, propositional knowledge in an accessible and easily comprehensible form (Novak & Cañas, 2006). In concept maps, individual concepts are depicted in individual boxes or circles. The concepts are interconnected with lines and arrows, representing the relationship between the concepts. For example, knowledge that a car has an engine would be represented by depicting "car" and "engine" in two separate boxes and connecting these with a line labeled "has a". Advanced digital concept maps additionally include hyperlinks with the concepts, enabling users to access information about the concept beyond what is depicted in the concept map (Tergan, 2005). A box featuring the concept of "engine" could thus contain a link to an online entry about car engines.

Several studies have demonstrated the value of providing individuals in collaborating groups with concept maps depicting their partner's knowledge structure and the underlying information (e.g. Engelmann & Hesse, 2010; Engelmann et al., 2010; Schreiber & Engelmann, 2010). For example, in one study (Engelmann & Hesse, 2010), group members working at a distance were each presented with a concept map depicting a portion of their group's knowledge. After acquainting themselves with their own assigned concept map, thereby becoming experts on their respective parts of the group's knowledge, group members were required to pool their knowledge in order to collaboratively solve a problem. During this collaborative phase group members in the experimental condition had access to their partners' concept maps, while group members in the control condition did not. The experimental groups, that is the groups who had CoKA, outperformed the groups without CoKA on the collaborative problem-solving task.

[4] In previous publications (e.g. Engelmann & Hesse, 2010; Engelmann & Tergan, 2007; Engelmann, Tergan, & Hesse, 2010; Schreiber & Engelmann, 2010) the term Knowledge and Information Awareness (KIA) was used. The new term, CoKA, was adopted to emphasize the unique focus on objective content-based knowledge awareness of the approach in contrast to the context-based or hybrid knowledge awareness approaches (cf. Engelmann, Dehler, Bodemer, & Buder, 2009).

1.4. Challenges for the CoKA approach

In order to increase the external validity of the CoKA paradigm, several studies (e.g. Engelman & Kolodziej, 2012) refrained from giving participants pre-built concept maps. Instead participants were asked to construct their own individual concept maps from lists of concepts and underlying relationships. These lists were intended to represent real world expert's notes on the subject. However, groups in which CoKA was established by giving group members access to each other's individually constructed concept maps performed at about the same level as groups without CoKA. This poses a problem for the CoKA approach since it suggests that in a real world application of CoKA, asking experts to generate representations of their knowledge structures to share with their partners at the beginning of a collaboration will not improve group performance.

A reason for the discrepancy in results between studies fostering CoKA via pre-made maps and studies in which CoKA is provided via individually constructed maps might be the individual participants' differences in map construction techniques. These might be so pronounced that the groups struggle to combine their individual knowledge during the collaborative phase of the studies. If incompatible concept maps are indeed the main reason for the reduction in CoKA effectiveness, however, then a simple solution could be to provide group members with awareness about each other's map construction process. Arguably, giving each group member insight into the other group members' map creation process should prompt the emergence of unified rules about the individual maps' form and structure. These "unified" individual maps should be as easy to integrate as the pre-made maps provided in previous studies. As observed with pre-made maps then, the CoKA provided through the unified maps should benefit group performance.

This approach aligns with previous studies on the development of norms in groups. According to past research (Feldman, 1984), groups tend to naturally develop and then adhere to rules which facilitate reaching the group's goal. Among other things, such rules tend make the group members' behaviors more predictable and comprehensible to the group. This clearly suggests that participants with insight into their group members' concept maps will develop more unified maps.

In CMC settings, Postmes, Spears, and Lea (2000) further confirmed the ease with which groups tend to develop homogenous rules of conduct. Based on their analysis of email exchanges within groups of online statistics learners, it was found that group members developed rules of interaction that were peculiar to the group they were in and did not necessarily apply outside of that group. According to Postmes et al. (2000), group norms are induced by mutual observations and interaction within the group. Moreover, the emergent norms in virtual teams tend to evolve from general group norms to more operationalized group norms (cf. Graham, 2003).

1.5. Summary

In summary, while collaboration can be advantageous, problems can emerge in particular in transiently collaborating groups relying on CMC. The CoKA approach has been shown to ameliorate some of the challenges of transient collaboration via CMC. The current study aims to overcome knowledge representation compatibility issues that transpired in attempts to increase the external validity of the paradigm, by giving the collaborators insight into each other's CoKA representation construction process.

2. Experimental study

In the present study, spatially distributed group members had to generate their own concept maps from lists of concepts and relationships between those concepts that were provided to them. In contrast to previous studies (e.g. Engelmann & Kolodziej, 2012), participants in the experimental groups had insight into the other group members' concept maps during the map construction phase, too. Participants in the control groups, on the other hand, were not given insight into each other's concept maps. Given the findings of Postmes et al. (2000), it was expected for the experimental groups that a unitary and stable group norm for concept map construction would emerge. Thus, their individual concept maps should be more compatible regarding their structure. Further, it was anticipated that, like CoKA of pre-made concept maps (cf. Engelmann & Hesse, 2010), having CoKA of the partners' knowledge, captured in "group normalized" concept maps, should increase group performance during the collaborative problem-solving phase. Thus the following hypotheses were tested:

Hypothesis 1. Regarding *development of group norms and orientation to group norms*, we expected that within the triads of the experimental condition, more structurally similar individual maps would be created compared to the maps within the triads of the control condition. We expect this outcome because individual members can observe each other's developing concept map while creating their own individual maps, which will lead to the development of a group norm regarding concept map "form".

Hypothesis 2. We expected a significant *interaction* of condition and structural similarity of the individual maps within the triads *on group effectiveness* (Hypothesis 2.1). More concretely, we expected that in the experimental condition with increasing structural similarity of the individual maps within the triads (i.e. concept map form convergence), the amount of correct problem solving will increase. In the control condition, however, the structural similarity of the individual maps within the triads should not have an effect on group effectiveness because the group members will never have access to each other's maps. In addition, we expected a significant *interaction* of condition and structural similarity of the individual maps within the triads *on group efficiency* (Hypothesis 2.2). More concretely, we expected that, in the experimental condition, with increasing structural similarity of the individual maps within the triads, the speed of correct problem solving will increase. In the control condition, however, the structural similarity of the individual maps within the triads should not have an effect on group efficiency.

2.1. Method

We compared two conditions each consisting of 20 triads. In the experimental condition while creating their own individual concept map, the members of the triads were able to observe the working windows of their group while they were creating their maps. All three individual concept maps remained visible in the subsequent collaboration phase. In the control condition, mutual observation during individual map creation was not possible and the partners' maps were not available in the collaboration phase.

Participants: In this study, participants were 120 German university students (94 female, 36 male) from different fields of study. They were on average 23.7 years (SD = 2.9) old and volunteered to participate for payment. The participants were randomly assigned to the conditions. All work was spatially distributed; each participant had his or her own room and own computer. The groups' gender composition was balanced between the two conditions (e.g. the same number of groups with no, one, two, or three men in each condition). The degree of acquaintance among the members in a triad was also controlled. For the most part, participants' reported that they did not know their collaboration partners; there was no

significant difference between the two conditions regarding acquaintance among the members ($F < 1$).

Materials: All materials used were in German (translated into English for the purpose of this paper). The problem scenario involved the rescue of a fictitious type of spruce forest comprising 13 concepts, 30 between-concept relations, and 13 pieces of information elements. These knowledge items were evenly distributed among the triad members in a way that each group member had equivalent amounts of shared and unshared elements. No one member was given sufficient information to solve the problem.

Control measures and supplementary materials: First, an online 34-item questionnaire was used to establish initial treatment condition equivalence. For example, one item measured participants' prior concept mapping experience. These items were mostly designed as five-point rating scales, ranging from complete agreement (5 points) to no agreement (1 point).

Second, a post-collaboration online knowledge test was used for measuring the knowledge acquired on one's own and also the team members' transactive knowledge. This test consisted of 24 items assessing whether a triad member remembered correctly which group member(s) initially had a specific piece of knowledge and how sure the participant was regarding the correctness of his or her answer. The first half of the items investigated memory for between-concept relations, and the second half investigated memory for specific concepts. To calculate the CoKA variable, the participants received one point for each correct answer. Each answer to an item was weighted by the certainty of the members that their answer was correct. The CoKA score is the sum of these weighted values. In addition, we calculated such scores for each task type separately.

Third, a post-collaboration online survey of participants' perceptions of the investigation was included consisting of 35 items in the control condition and 54 items in the experimental condition, with additional items measuring the perceived usefulness of the possibility to observe the partners' creation of their individual concept maps and the availability of CoKA in the collaborative phase. In addition to these online inventories, the triad members had access to paper-based instructions for learning to use CmapTools, a free digital concept mapping software (see http://ftp.ihmc.us/), and paper-based instructions to explain the procedure of the study.

Procedure: After all triad members had met in one room and had been introduced to the study framework, they were sent to their separate rooms to sign a written agreement to take part in the study. The study began by filling out the online questionnaire for assessing the control measure items, which was followed by CmapTools practice. All participants had enough time (up to 20 min) to sufficiently learn how to use this software. After this preparation phase, the main study started. First, the triad members were individually introduced to the group tasks; that is, that they were to imagine that they are a team of three experts that had been enlisted in order to rescue a specific spruce forest. They were informed that they have to collaboratively solve two problems, first deciding which pesticide should be used to combat a threat to the spruce forest, and second, deciding which fertilizer is needed to mitigate the effects of the pesticide. Thus the fertilizer problem depended on the decision made regarding the pesticide problem.

In the individual phase, the group members had to create their individual concept maps based on one of three unique expert documents (e.g. referred to as documents A, B, and C) with largely non-overlapping material, containing a portion of the total individual pieces of knowledge needed to solve the problem scenario. Thus each member of the triad had different information, and the two problems could only be solved by combining information (i.e. hidden profiles). In the experimental condition, participants had access to the working windows of their collaboration partners who created their individual maps at the same time (see Fig. 1). This means that the group members of the experimental condition while creating their own map could observe the creation process of their collaboration partners' maps. However, it was not allowed to make changes in the partners' maps or to directly communicate with the partners. In the control condition, each team member only had access to their specific text document (e.g. A, B, or C) and their own working window for creating their own individual concept map. This creating phase lasted 23 min.

Afterwards the triad members had another 3 min to look over their self-created maps, and in the experimental condition to look over their own and their collaborators' individual maps. In the following collaborative phase, the triad members had 35 min to collaboratively solve the pesticide and fertilizer problems. To be able to do this, they had to compile their individual knowledge and information by creating together a group concept map in their shared working window. In this phase, they could communicate via Skype (only audio). The answers to the problem tasks had to be written on a sheet of paper together with the explanation regarding why they chose this particular answer. In this phase, the group members of the control condition had access to the shared working window for creating the group concept map and their own working window containing their own individual concept map (i.e. without CoKA). In the experimental condition, the group members additionally had access to the working windows of their partners' concept maps (i.e. with CoKA). After this collaborative phase, each triad member was asked to solve individually an online knowledge test (without having access to the concept maps) and to fill out the online evaluation questionnaire, both without time limits. Finally, the students were debriefed, and then thanked and rewarded for their participation.

2.2. Predictor measures

Beside the conditions (experimental vs. control condition), the following predictors for assessing structural similarity of the individual concept maps within the triads were used in the study:

Standard deviation regarding number of correct nodes ($SD_{\text{number nodes}}$): To calculate this measure, first the number of correct nodes in each of the three individual maps of a triad was counted (max. attainable score = 9 points). Second, these three values of a triad were aggregated by using the standard deviation. This means that if this value is high, the three maps of a triad were very different regarding the number of correct nodes, while if this value is zero, the three maps are identical regarding the number of included correct nodes.

Standard deviation regarding number of correct relations ($SD_{\text{number relations}}$): To determine this measure, the number of correct relations in each of the three individual maps of a triad was counted (max. attainable score = 13 points). These three values of a triad were also aggregated by using the standard deviation. This means that with increasing value, the three maps increasingly differ regarding the number of correct relations.

2.3. To measure content structural similarity of the maps, we used the following predictor

Content structural similarity based on centrality ($SS_{\text{centrality}}$): Following a method described by Clariana, Engelmann, and Yu (2013) for capturing content structural information in concept maps, individual students' maps were converted to node degree vectors using the 15 most frequent important terms. Then these team members' map vectors were compared to each other by Pearson correlation (e.g. members A to B, B to C, A to C). Since Pearson r values are not additive, these r values were transformed to Fisher z values, and then the three z values for each team were averaged to

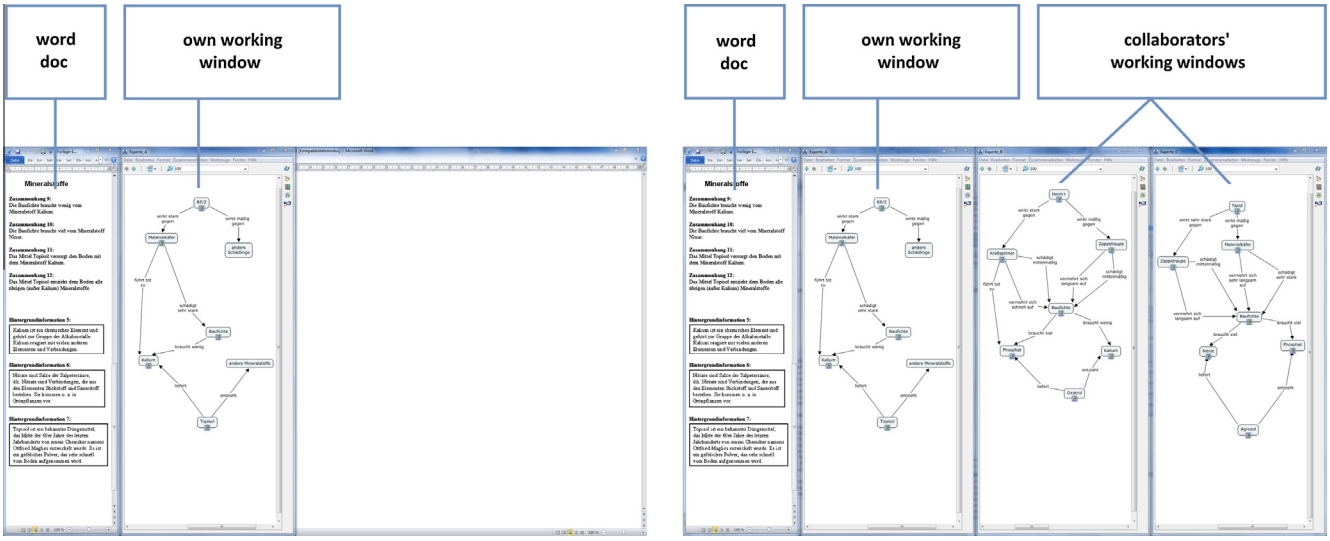

Fig. 1. Computer screen of the control condition (left side) and the experimental condition (right side) in the individual map construction phase.

obtain a team similarity score. For interpretation purposes, note that for Pearson *r* values between −0.40 and +0.40, the *r* and *z* values are nearly identical (e.g. Fisher $z = 0.151$ is Pearson $r = 0.150$). Thus each team has a similarity score expressed as an average Fisher *z* value where larger values indicate greater similarity (team member convergence). This approach was also applied to estimate the content structural similarity between the individual concept maps and the three referent expert maps of each of the three expert documents, A, B, and C, that contained the individual pieces of knowledge that were given to each member in a triad (individual convergence with the expert document).

2.4. Criterion measures

To test Hypothesis 1, we used the three map similarity measures $SD_{\text{number nodes}}$, $SD_{\text{number relations}}$, and $SS_{\text{centrality}}$ (described above) as criterions. In addition, to substantiate this hypothesis, we also included two log file measures:

Number of moves of nodes (log $\text{file}_{\text{move nodes}}$): This measure consists of log file data with regard to the number of node moves in an individual map. For each move of a node in an individual map, one point was given.

Number of moves of relations (log $\text{file}_{\text{move relations}}$): This measure refers to log file data with regard to the number of relation moves in an individual map. For each move of a relation in an individual map, one point was given.

Due to the fact that the fertilizer problem could only be solved if the pesticide problem was solved correctly, and therefore for solving the pesticide problem exclusively, the three individual concept maps were critical, in the following we will only report the results with regard to the pesticide problem. To test Hypotheses 2, collaborative problem-solving performance was assessed by the following measures:

Solution potential of the group map with regard to the pesticide problem (Solution $\text{potential}_{\text{group map}}$): If a group map created by a triad contains all relevant information aspects that were needed to solve the problem, one point was given. If aspects were missing or if some of them were wrong, no points were given.

Correctness of solving the pesticide problem (group effectiveness): The calculation of this measure follows two rules: First, one point was given if a triad chose the correct pesticide (only one correct solution was possible), while no points were given if a triad chose a wrong one.

Only if a triad chose the correct solution, the reasons given by the group to explain why they had chosen this pesticide were analyzed. A maximal sum of three points was possible to attain for the correct solution. This means that maximal 4 points were attainable for a correct solution and all correct reasons, while zero points were given for a wrong solution.

Speed of correct solving the pesticide problem (group efficiency): For all triads that chose the pesticide problem correctly, the time was assessed how long they had needed to solve this problem. It was calculated as the time of the final group decision for the correct pesticide minus the starting time of the collaboration phase.

3. Results

All analyses presented here are based on the group level because the members in a triad are not independent of each other. For data measured on an individual level, group values were calculated. The analyses of the control measure items showed that we did not need to include a covariate.

3.1. Manipulation check

We first checked whether the group members were able to convert the pieces of information in their expert documents into apposite, individual concept maps. To do this, all of the individual map content structural similarity vectors ($SS_{\text{centrality}}$) were compared to the vectors of expert maps A, B, and C created based on the expert documents of A, B, and C (see Table 1). The data clearly shows that the content structure of participants' maps strongly aligned with the appropriate expert map of that information (i.e. estimated $r > .73$). For example, those who were given expert document A created a concept map that matched the expert's map of content A, and it did NOT match the expert's maps of content B or C. This was true for both the control and the experimental conditions, even though the maps from the control condition members may be a little more like their corresponding expert document derived expert map (e.g. estimated *r* values, CC = .79 and .85 and .89 vs. EC = .82 and .73 and .78).

In this study, we manipulated two aspects: First, in the individual phase, the members of the experimental groups were able to observe each other's map construction process, the members of the control condition had only access to their own working

Table 1
The average content structural similarity of the individual concept maps when compared to the expert maps based on the word documents A, B, and C.

	To expert map A		To expert map B		To expert map C	
	Fisher *z*	*r* est.	Fisher *z*	*r* est.	Fisher *z*	*r* est.
CC (control)						
Individual maps of experts A	1.06	0.79	0.08	0.08	0.03	0.03
n = 20	(0.59)		(0.23)		(0.24)	
Individual maps of experts B	0.07	0.07	1.24	0.85	0.09	0.09
n = 20	(0.22)		(0.82)		(0.20)	
Individual maps of experts C	0.19	0.19	0.14	0.14	1.42	0.89
n = 20	(0.21)		(0.21)		(0.73)	
CE (experimental)						
Individual maps of experts	1.16	0.82	0.11	0.10	0.06	0.06
n = 20	(0.82)		(0.23)		(0.23)	
Individual maps of experts	0.01	0.01	0.94	0.73	0.04	0.04
n = 20	(0.24)		(0.50)		(0.23)	
Individual maps of experts C	0.07	0.07	0.01	0.01	1.05	0.78
n = 20	(0.24)		(0.25)		(0.81)	

Note: Standard deviations shown in parentheses.
Pearson *r* estimate calculated as Fisher inverse using Microsoft Excel FISHERINV function.

window in which they created their own map. The fact that seeing the others' map construction progress was useful is shown by the items assessed in the online evaluation questionnaire: The members of the triads in the experimental condition perceived the possibility of seeing the partners' maps construction process while their own map creation as rather helpful ($M = 3.58$; $SD = .64$). They also stated that they partly compared their own map with the partners' maps during the construction process ($M = 3.58$; $SD = .55$) and that seeing the others' maps while creating their own maps gave them in part orientation for their own map creation ($M = 3.28$; $SD = .49$).

However, interesting to mention are the following unexpected descriptive results: The members of the experimental condition indicated that they had tried not to create maps that were similar to those of their partners ($M = 2.15$; $SD = .61$) and that they had created their map in their own way even though they had seen the others' maps ($M = 3.92$; $SD = .52$). But they did report that the fact that they were able to observe the creation of the partners' maps led partly to similar maps ($M = 2.97$; $SD = .55$).

Second, in the subsequent collaborative phase, besides the shared working window and their own working window, the members of the experimental condition could still see the working windows of their collaboration partners containing their individual concepts maps. The members of the control groups had only access to the shared and their own working window. Descriptive data assessed by the online evaluation questionnaire demonstrated that the members of the experimental condition felt confident navigating their partners' maps ($M = 3.78$; $SD = .51$) and understood their partners' maps well ($M = 4.09$; $SD = .49$). In the collaborative problem-solving phase, the members of the experimental groups stated that seeing the partners' maps was helpful ($M = 4.08$; $SD = .69$), helped them to get a clear perception of the partners' expertise ($M = 3.85$; $SD = .64$), and helped to avoid misunderstandings ($M = 3.78$; $SD = .64$).

The knowledge test used after the collaboration phase resulted as expected in a significant difference between the conditions: ANOVAs showed that compared to the control condition, the members of the experimental condition acquired marginally more CoKA ($M_C = 20.20$; $M_E = 24.26$; $F(1, 38) = 3.88$; $MSE = 42.63$; $p = .056$). Especially regarding the second type of knowledge tasks, focusing on knowing which of the three triad members had information on particular concepts, the experimental condition groups acquired significantly more CoKA ($M_C = 10.44$; $M_E = 13.01$; $F(1, 38) = 5.05$; $MSE = 13.06$; $p = .031$).

3.2. Results on differences between the conditions regarding the structural similarity of individual maps within triads

All statistics for these findings are presented in Table 2.

Structural similarity of the individual maps was assessed by the measures $SD_{\text{number nodes}}$, $SD_{\text{number relations}}$, $SS_{\text{centrality}}$. Due to the fact that the requirements for conducting ANOVAs were not given, because of missing variance homogeneity, we calculated Welch tests:

Standard deviation regarding number of correct nodes: The Welch test analysis with condition as the independent measure and $SD_{\text{number nodes}}$ as the dependent measure demonstrated as expected that within the triads in the experimental condition more similar maps were created compared to the maps within the triads of the control condition.

Standard deviation regarding number of correct relations: The Welch test analysis with condition as the independent measure and $SD_{\text{number relations}}$ as the dependent measure also showed as expected that within the triads in the experimental condition more similar maps were created compared to the maps within the triads of the control condition.

Content Structure Similarity based on centrality: Since the individual maps in a team should represent information elements from the expert documents A, B, and C that are to a large extent non-overlapping elements, these maps should then rarely be related in the control condition (CC). A larger overlap in the experimental condition (EC) would have to be the result of information transfer from the other members' onscreen maps to that member's map in progress. The Welch test analysis with condition as the independent measure and $SS_{\text{centrality}}$ as the dependent measure showed, as expected, that map average structure similarity within the triads in the experimental condition were significantly more alike than those within the triads of the control condition. In fact, the control condition had nearly zero map content structure similarity.

Further analyses support these findings of a higher similarity of the individual maps within the triads in the experimental condition compared to those of the control condition, namely, our log file analyses:

A Welch test analysis of condition on log $\text{file}_{\text{moving nodes}}$ as well as the one on log $\text{file}_{\text{moving relations}}$ demonstrated significantly more movement of nodes and relations in the individual maps in the experimental condition compared to the control condition. These results give evidence for a stronger mutual adaption of the individual maps in the experimental compared to the control condition.

Table 2
Welch's test results on differences between the conditions regarding the structural similarity of individual maps within triads.

	MCC	MEC	*t*	*df*	*p*	*d*
Standard deviation number of nodes	2.282	1.459	2.12	29.63	.043	.67
Standard deviation number of relations	3.387	1.961	2.87	27.40	.008	.91
Structural similarity as node degree[a]	0.029	0.151	5.07	36.12	.030	.70
Mean number of node moves	66.93	139.40	−2.18	23.40	.040	.69
Mean number of relation moves	61.18	136.65	−2.21	26.53	.036	.70

Notes: CC = Control Condition; EC = Experimental Condition.
[a] Averaged Fisher *z*.

3.3. Results on the interaction of condition and structural similarity of the individual concept maps on collaborative problem-solving

The details of the analytical procedures are described in the appendix. All statistics for these findings are presented in Table 3.

Solution potential$_{\text{group map}}$: The regression analysis with condition, structural similarity of the individual maps with respect to the *standard deviation regarding number of correct nodes* ($SD_{\text{number nodes}}$), and their interaction as predictors and solution potential of the group map (Solution potential$_{\text{group map}}$) as criterion did not result in the expected significant interaction.

However, the regression analysis with condition, structural similarity of the individual maps with respect to the *standard deviation regarding number of correct relations* ($SD_{\text{number relations}}$), and their interaction as predictors and solution potential$_{\text{group map}}$ as criterion led to the expected significant interaction: The simple slope analysis resulted in the expected type of interaction: While in the experimental condition increasing structural similarity within the individual triad maps regarding the number of relations led to improved solution potential of the group map, in the control condition the similarity of the individual maps within a triad did not have an effect on the solution potential$_{\text{group map}}$.

Group effectiveness: The regression analysis with condition, structural similarity of the individual maps with respect to the *standard deviation regarding number of correct nodes*, and their interaction as predictors and the correctness of solving the pesticide problem as criterion did not result in the assumed significant interaction.

However, the regression analysis with condition, structural similarity of the individual maps with respect to the *standard deviation regarding number of correct relations*, and their interaction as predictors and the correctness of solving the pesticide problem as criterion resulted in the expected significant interaction. The simple slopes analysis led to the expected findings: In the experimental condition, with increasing structural similarity with regard to relation numbers within the triads, the group effectiveness increases, that is, the more map similarity, the more correct collaborative problem solving arises. In the control condition, however, the structural similarity regarding relations within the triads had no effect on the correctness of the collaborative problem-solving.

Group efficiency: The statistical requirements for conducting regression analyses were not given. Therefore, we calculated correlations between structural similarity measures and group efficiency for each condition.

In the experimental condition, the structural similarity of the individual maps with respect to the *standard deviation regarding number of correct nodes* correlated marginally with group efficiency ($r = -0.42$; $p = .07$), while in the control condition no significant correlation between these two measures existed ($r = -0.23$; n.s.),

In addition, as assumed in the *experimental condition*, the structural similarity of the individual maps with respect to the *standard deviation regarding number of correct relations* correlated significantly with group efficiency ($r = -0.50$; $p < .05$); that is. with increasing similarity of the individual maps, the problem was solved faster. However, in the control condition, the structural similarity of the individual maps with respect to the *standard deviation regarding number of correct relations* did not correlate significantly with group efficiency ($r = -0.08$; n.s.).

4. Discussion

The initial point of the paper was that in studies with self-created individual maps as a means for CoKA (i.e., to make group members aware of what their group partners know and what underlying information they have), the positive effect on computer-supported collaborative problem solving performance was diminished (e.g. Engelmann & Kolodziej, 2012). This was in contrast to studies using pre-made partial expert maps for CoKA (e.g. Engelmann & Hesse, 2010). The assumed reason for these different findings was that the self-created maps are too different to process them easily.

In this paper, a possible solution for this problem was investigated: While creating their own individual map to visualize their own knowledge and information presented in an expert document, the group members of the experimental condition ($N = 20$ triads) had the possibility to observe the other members' map creation process. This should lead to norm development regarding how to create such a map, an orienting effect. This should result in more structurally similar maps and as a consequence an increase in the effectiveness of the CoKA approach as in studies with pre-made individual maps. The members of the control groups ($N = 20$ triads) did not have this possibility to see the others' maps. These expectations regarding norm development and norm orientation were derived from empirical studies, for example, by Postmes et al. (2000) that demonstrated that groups interacting computer-supported develop norms naturally among each other by mutual observations.

The results of the current investigation show that the group members of both conditions were able to create adequate individual maps based on elements in their assigned expert document. In addition, questionnaire items show that the members of the experimental condition did observe the map development of their partners. They also stated that this gave them, in part, orientation for their own map. It is interesting that they also mention that they had tried not to create maps similar to their partners' maps, but they also report that seeing the partners' map construction led to similar maps. These findings seem to show that participants preferred not to admit that they oriented themselves to the others, but it seems that they had perceived that the finished maps looked similar.

In addition to these subjective impressions, the data demonstrates that the individual maps of the experimental groups were significantly more structurally similar compared to those of the control groups. Structural similarity was assessed based on number of correct nodes and correct relations, while content structural similarity was assessed by node centrality. These results confirm Hypothesis 1. These results were also substantiated by the log file findings. The members of the experimental groups did more often

Table 3
The results of the moderator analyses of condition and structural similarity of the individual maps within the triads on collaborative problem-solving.

Criterion variable	Predictor variables	*b*	SE	*β*	*p*	Model properties		
						Adj. R^2	*F*(*df*)	*p*
Group effectiveness	Standard deviation regarding number of nodes	−0.24	0.33	−0.15	.47	[−.009]	[0.83(2,37)]	[.45]
	Condition	−0.10	0.28	−0.06	.72			
	SD number of nodes × condition	0.21	0.33	0.12	.52	−.025	0.68(3, 36)	.57
Group effectiveness	Standard deviation regarding number of relations	−0.58	0.36	−0.36	.11	[−.048]	[0.11(2,37)]	[.89]
	Condition	−0.27	0.29	−0.17	.37			
	SD number of relations × condition	−0.72	0.36	−0.40	.05	.032	1.42(3,36)	.25
	Simple slope CC	0.14	0.31	0.08	.66			
	Simple slope EC	−1.30	0.64	−0.81	.05			
Solution potential of the pesticide problem in the group map	Standard deviation regarding number of nodes	−0.18	0.10	−0.36	.08			
	Condition	−0.06	0.09	−0.12	.50			
	SD number of nodes × Condition	−0.13	0.10	−0.25	.19	.012	1.16(3,36)	.34
Solution potential of the pesticide problem in the group map	Standard deviation regarding number of relations	−0.25	0.11	−0.49	.02	[−.039]	[0.28(2,37)]	[.76]
	Condition	−0.10	0.08	−0.21	.25			
	SD number of relations × condition	−0.29	0.11	−0.52	.01	.112	2.64(3, 36)	.06
	Simple slope CC	0.04	0.09	0.08	.65			
	Simple slope EC	−0.54	0.19	−1.06	<.01			

Notes: Values in brackets represent the model properties before the inclusion of the interaction. The continuous predictor variable in question was *z*-standardized.
Simple Slope CC = Simple slope analysis for the control condition.
Simple Slope EC = Simple slope analysis for the experimental condition.

move their nodes and relations in their individual maps compared to the members of the control groups. This could also be evidence for a stronger mutual adaption of the individual maps in the experimental condition. These findings provide evidence that mutual observation during the map creation process leads, as expected, to the development of implicit group norms. Our findings therefore contribute to the research gap that Graham (2003) had highlighted as he pointed out the importance of investigating "how technological affordances help to establish implicit norms" in virtual teams.

We also expected that with increasing similarity of the individual maps in the experimental condition, group performance would increase, while similarity should not have an effect in the control condition. Group performance was measured by solution potential of the group map, by group effectiveness, and by group efficiency. Our analyses confirmed the expected interaction between condition and structural similarity on all three group performance measures for the similarity variable "standard deviation regarding the number of correct relations". That is, in the experimental condition, with increasing structural similarity between the three individual maps within a triad, the triads created group maps with higher solution potential, solved the problem more often correctly, and were faster in solving the problem correctly. These results support Hypothesis 2 that being able to see the map creation process of the partners leads to improved group performance.

These findings demonstrated that the possibility of observing the map creation process of partners is a viable way to make self-created maps effective for the CoKA approach. However, it should be noted that with increasing similarity of the individual maps, the group performance improved. This means that the experimental groups differ regarding the amount of similarity of their individual maps; that is, the possibility of mutual observation did not have the same effect in all groups. Future research should consider which type of groups benefit most from mutual observation and which type of groups do not.

In contrast to our expectations, we did not find this pattern of results for the similarity measure "standard deviation regarding the number of correct nodes". One possible explanation could be that for solving this problem, the between-concept relations are much more important than the nodes. Findings of a prior study seem to confirm this explanation. In the study by Engelmann and Hesse (2011), the experimental groups only had access to the node information of the others, but not to the relation information. As a result, the experimental groups did not outperform the control groups regarding collaborative problem-solving performance.

The analysis of the questionnaire assessed after the collaboration phase corroborates our findings: The members of the experimental condition stated both that they were confident regarding navigating their partners' maps and that they understood the others' maps. Since in prior studies with individually-created concept maps, the members had problems in using their partners' maps due to their large variance in map structure, this answer provides evidence that in the present study the implicit fostering of the creation of similar maps through the possibility of mutual observation was successful. These findings are further corroborated by the perceived helpfulness of having access to the partners' individual maps during the collaboration phase. The group members of the experimental condition explained that it helped them to recognize their partners' expertise and to avoid misunderstandings. In addition, the analysis of the knowledge test after the collaboration phase revealed that the experimental groups acquired more CoKA compared to the control groups. This is also evidence that the individual maps were processed in the experimental groups.

5. Implications

Prior studies (e.g. Engelmann & Hesse, 2010; Engelmann et al., 2010) have shown that having access to the collaboration partners' knowledge structures and underlying information fosters computer-supported problem-solving. But due to the experimental design of those studies, the awareness content was pre-made by experts. In order to foster ecological validity of the CoKA approach, the members need to externalize their knowledge on their own; that is, they should create the awareness contents by themselves that would then be provided as CoKA information to their partners. However, prior studies (e.g. by Engelmann & Kolodziej, 2012) have observed a large variance within the self-created awareness contents leading to the fact that their use for CoKA was not effective anymore. This current investigation highlighted the effective strategy of mutual observation during the awareness content creation process. This simple solution makes the CoKA approach effective also in a more ecologically valid setting in which the group members externalize their knowledge and their information on their own.

Appendix A. Analytical procedures

Due to the fact that we were interested in interaction effects between condition and variables of trust, as well as between condition and variables of collaboration quality, regression analyses were conducted. More concretely, moderator analyses were conducted following Aiken and West (1991). The necessary requirements for conducting regression analyses were tested in each time, that is, for each analysis the global test statistic was calculated: The global test statistic as a function of the model residuals "is formed from four asymptotically independent statistics, each with the potential to detect a particular violation" (Peña & Slate, 2006, p. 353). These independent statistics are linearity, homoscedasticity, uncorrelatedness, and normality. In this paper, only those analyses are reported that met the global test statistic.

For condition as a categorical moderator variable, unweighted effects coding was used (control condition = −1, experimental condition = +1) because then, the regression coefficients represent the difference between each condition's mean and the unweighted mean of both conditions (Cohen, Cohen, West, & Aiken, 2002). *Z*-standardization was applied on all other predictors because they were continuous variables. Like centering, *z*-standardization eliminates the problems of multicollinearity between the categorical moderator variable and the specific continuous predictor variable. In addition to this, it simplifies the comparison of significant moderator effects on different criterion variables and eases their plotting (Aiken & West, 1991; Cohen et al., 2002; Frazier, Tix, & Barron, 2004).

To calculate the moderator analyses according to Aiken and West (1991), a first series of regression analyses was calculated with only the moderator and another predictor as predictor variables and an outcome measure as the criterion variable. This first series of regression analyses was needed to obtain the change in adjusted R^2 in a second series of regression analyses with the same variables and also – by multiplying the moderator with the other *z*-standardized predictor – the interaction term for the additional explained variance of the interaction. To test the significance of the simple slopes for each level of the categorical moderator variable, two additional regression analyses were conducted (Aiken and West, 1991; Frazier et al., 2004): To test the significance of the simple slope for the control condition, a dummy coding of control condition = 0 and experimental condition = 1 was applied. For the significance of the simple slope for the experimental condition, a dummy coding of control condition = 1 and experimental condition = 0 was applied. Regression analyses were calculated with one of these newly coded moderators, another predictor, as well as their interaction term as predictor variables, and an outcome measure as the criterion variable.

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APPENDIX B – SUBMITTED PAPERS

Group Decision and Negotiation

Priority Awareness Outperforms Performance Awareness in Negotiations

--Manuscript Draft--

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Full Title:	Priority Awareness Outperforms Performance Awareness in Negotiations
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Abstract:	Being aware of the priorities of the partner has been shown to play a crucial role in successful negotiations. More awareness has the potential to further improve different measures of negotiation performance, reducing the fixed-sum-error and the incompatibility error and thus leading to a better economical outcome. Fostering more awareness with the help of more information and communication technology's abilities runs the risk of failing to improve negotiations. The cognitive load theory, the regret theory, and the strategic misrepresentation of information are possible explanations. We compared two tacit approaches of creating awareness in a computer-supported negotiation: (1) The priority awareness approach, utilizing non-interactive bar charts and (2) the performance awareness approach, utilizing interactive bar charts. One hundred and thirty-two participants negotiated in 66 dyads in a car buying/selling scenario, 33 dyads per approach. The two awareness approaches neither differed in joint outcome nor pareto efficiency; however, the dyads negotiating with the interactive performance awareness were less satisfied, liked their partner less, thought their agreement was less fair - although there was no difference in fairness - and they were more deceitful in their negotiation, also perceiving their partner as more deceitful. Further, they showed a different behavior in dealing with information for future negotiations. The potential benefits of more awareness could not be realized. The reasons for this could be a too complex approach, feelings of regret witnessing previous possible agreements, and fewer opportunities for strategic misrepresentation of information. Non-interactive bar charts are simple and cheap; they suffice for improving negotiation performance.

Priority Awareness Outperforms Performance Awareness in Negotiations

Abstract

Being aware of the priorities of the partner has been shown to play a crucial role in successful negotiations. More awareness has the potential to further improve different measures of negotiation performance, reducing the fixed-sum-error and the incompatibility error and thus leading to a better economical outcome. Fostering more awareness with the help of more information and communication technology's abilities runs the risk of failing to improve negotiations. The cognitive load theory, the regret theory, and the strategic misrepresentation of information are possible explanations. We compared two tacit approaches of creating awareness in a computer-supported negotiation: (1) The priority awareness approach, utilizing non-interactive bar charts and (2) the performance awareness approach, utilizing interactive bar charts. One hundred and thirty-two participants negotiated in 66 dyads in a car buying/selling scenario, 33 dyads per approach. The two awareness approaches neither differed in joint outcome nor pareto efficiency; however, the dyads negotiating with the interactive performance awareness were less satisfied, liked their partner less, thought their agreement was less fair – although there was no difference in fairness – and they were more deceitful in their negotiation, also perceiving their partner as more deceitful. Further, they showed a different behavior in dealing with information for future negotiations. The potential benefits of more awareness could not be realized. The reasons for this could be a too complex approach, feelings of regret witnessing previous possible agreements, and fewer opportunities for strategic misrepresentation of information. Non-interactive bar charts are simple and cheap; they suffice for improving negotiation performance.

Keywords: awareness, negotiation support system, interactivity, negotiation, performance, priority

Priority Awareness Outperforms Performance Awareness in Negotiations

1 Introduction

Successful negotiations strongly rely on the negotiators dealing with priorities. Taking a car purchase as a scenario which most people can relate to, it is easy to imagine that the buyer and seller have different priorities of issues that they are going to negotiate and that both want to achieve the best possible outcome for themselves. The seller may be interested in a high financing rate and selling many extras, and the buyer may be interested in an extended warranty and the latest multimedia system. As no side will just give in to the demands of the other without concessions from the other, the most profitable solution would be to give in on less important issues and in exchange insist on more important ones. This approach is known as integrative negotiation (Barry and Friedman 1998; De Dreu et al. 2007) and leads to agreements which are not only more satisfying but economically more beneficial for both. Only when both negotiators are aware of their different priorities can they exchange concessions. This awareness is rarely the case and even experienced negotiators fall prey to wrong assumptions about priorities which in turn lead to suboptimal agreements (Thompson and Hastie 1990).

In this experimental study, we attempted to find a tacit and unobtrusive way to foster awareness in negotiations, adjusting for such wrong assumptions and thus improving negotiation performance. Computerized negotiation support systems (Kersten and Lai 2007) exist in real life applications such as “Zopaf” (Andinian Inc. 2015) or “Smartsettle” (iCan Systems Inc. 2015) and also in experimental applications such as “Inspire” (Kersten and Noronha 1999) or “Negoisst” (Schoop et al. 2003). These applications have different means of supporting the negotiators with relevant information and have been shown to have a positive effect on negotiation performance (Rangaswamy and Shell 1997; Foroughi 1998; Filzmoser et al. 2010). We have built an experimental negotiation support system with which we compare two approaches for creating awareness in a way that does not need any special prerequisites in form of explicit instructions or training to carry out an integrative negotiation. Both approaches make use of bar charts: One uses non-interactive bar charts as commonly seen in business reports or on the news for creating awareness of priorities in a negotiation. The other uses interactive bar charts, changing in size with the input of the negotiators and creating awareness about their current performance. Although the interactive approach with more awareness has a strong potential to improve agreements further than the one with less, there is also a strong risk of it actually hampering benefits or even leading to negative consequences. The cognitive load theory (Chandler and Sweller 1991), the regret theory (Loomes and Sugden 1982; Bell 1982), and the strategic misrepresentation of information (Steinel and De Dreu 2004) give reason to assume negative effects.

By the end of this article, we will have shown how these two approaches differ in their effect on the actual negotiation performance, whether the amount and interactivity of awareness plays a role, and which approach would be the most beneficial – economically or otherwise – for the use in a negotiation.

2 The Importance of Priorities in Negotiations

The non-awareness of differences in priorities has been shown to lessen the joint outcome of a negotiation – the sum of the point values of both negotiators given to their agreement. Thompson and Hastie (1990) have coined the terms fixed-sum-error and incompatibility error which are a direct result of not being aware of the others priorities. Regarding the first error, the negotiators wrongly assume that they both have the same priorities of issues, although they do not. Regarding the second error, the negotiators wrongly assume that they have different priorities of options within the issues, although they do not. These errors are also made by experienced negotiators (Thompson 1990) and in the case of the incompatibility error, they sometimes lead to lose-lose-agreements in which both agree on a common loss (Thompson and Hrebec 1996).

On the other hand, multiple studies have shown, that awareness about the priorities of the other negotiation party leads to a higher joint outcome. These studies relied either on the previous experience of the negotiators and their knowledge about the importance of priorities (Thompson and Hastie 1990; Hyder et al. 2000; Schei et al. 2006) or on explicit instructions to think about priorities (Foroughi et al. 1995).

3 Fostering Priority and Performance Awareness

“Priority awareness” is a term formally coined by de Jong, Tuyls, Verbeeck and Roos (2008) in the context of negotiations. It is a way of making a negotiation algorithm aware of priorities and model it so as to mimic human behavior where sometimes trade-offs are made based on different priorities. Our definition replaces the algorithm with a human: Priority awareness is the awareness of the negotiator of their priorities.

Priority awareness can be fostered by presenting the negotiators their different priorities of issues with bars sized accordingly. These bars do not change their size by the choice of different options in the negotiation. They look the same from the beginning to the end.

“Performance awareness” is a concept from learning sciences that might be likewise relevant for negotiations. It is either understood as the quality of the estimation of performance accomplished in a

learning setting (Pressley and Ghatala 1988; Hershey and Wilson 1997; Sağlam 2010) or the monitoring of the current performance in a learning setting (Wade and Reynolds 1989; Devolder et al. 1990; Chen et al. 2001). In the context of negotiations, performance awareness is the awareness of the negotiator about the state of their current performance.

Performance awareness can be fostered by presenting to the negotiators their different priorities of issues with transparent bars sized accordingly and their priorities of options with horizontal lines which fill up to bars, dependent on the chosen options. These bars change in size during the process of the negotiation.

We feel a comprehensive order of psychological steps needed for the effectiveness of every method for creating awareness (see Table 1). An automatic thinking process should be nudged (Thaler and Sunstein 2009) without further guidance.

[INSERT TABLE 1 ABOUT HERE]

Both approaches use a graphical decision aid to foster awareness, but while the bar charts for fostering priority awareness are non-interactive, as usually encountered in real life or business settings, the bar charts for fostering performance awareness make more use of the information and communication technology abilities to interactively change in size. Adding interactivity and creating awareness of the current performance could have an influence on the first three psychological steps and affect the commitment of fixed-sum-error as well as the incompatibility error (Thompson and Hastie 1990):

Creating priority or performance awareness is dependent on the negotiators perceiving the bar chart per se before understanding that it is about differences in priorities, and finally interpreting it accordingly, using this information to beneficially integrate their different priorities. Chun (2000) and Wolfe and Horowitz (2004) have shown that size and motion undoubtedly draw attention. Compared to the non-interactive priority awareness approach, using an interactive approach to directly change the size of bars could draw greater attention to the bar chart and increase it being perceived. The additional observation of how the bars change with different chosen options could ease the negotiator's understanding of the content of the bar chart. Through the interactivity, the negotiator's interpretation of the bar charts function and utility could be facilitated and further counteract the fixed-sum-error (Thompson and Hastie 1990), thus further improving the negotiation performance.

Performance awareness is realized along with priority awareness. When referring to priorities in negotiations, it is generally a reference to priorities of issues such as, for example, financing or warranty in a car buying/selling scenario. With performance awareness, we differentiate between priorities of issues and the priorities of options within each issue, for example, the options “6 months”, “12 months”, “18 months”, “24 months”, and “30 months” within the issue warranty. The study by Rasch and Schnotz (2009) showed that the ability to interactively change the representation of information to find the correct differences in a numerical task with a visual representation (finding time-differences between capital cities around the world) enabled the participants to represent multiple states which they could not have accessed with a non-interactive visualization. This enabled them to process more and achieve a better performance in a task in which they had to repeatedly extract information from a large set of different solution states. Making not only the priorities of issues but also the priorities of options salient in a negotiation could have an influence on the commitment of the incompatibility error, where negotiators agree on a suboptimal option for both (Thompson and Hastie 1990).

Performance awareness has the potential to outperform priority awareness, but interactivity and more awareness do not automatically equal better outcomes. The interactive bar charts could also be the reason why performance awareness will underperform in comparison.

The regret theory (Loomes and Sugden 1982; Bell 1982) states that people may feel regret when they reflect on how much more preferable another position would have been, had they chosen differently, and this reflection may reduce the pleasure that they derive from their choice. Larrick and Boles (1995) have shown the consistency of this effect in a negotiation scenario. Creating awareness about the current performance, with the negotiators remembering what was and what could have been, could lead to regret and undermine otherwise existent benefits of priority awareness.

Another point of doubt on why an approach with interactive bar charts might not be as beneficial as a non-interactive approach, comes with the cognitive load theory (Chandler and Sweller 1991). Interactive bar charts are inherently more complex than non-interactive bar charts; there is just more information that has to be processed such as how to change the size of the bar charts, what the change in size means, and what the current size means. A higher cognitive load also leads to less satisfaction with a computer system (Schmutz et al. 2009). While there is more information available with the performance awareness approach, one also needs more cognitive resources for processing, which could have a negative influence on negotiation performance.

A third problem appears with the observed strategic misrepresentation of information in negotiations (Steinel and De Dreu 2004). People seem to disclose a lot of information but do not want to disclose too much information in order to be able to have some degrees of freedom in performing the

negotiation in their favor, meaning that they also want to have the choice of giving or holding back information. Performance awareness does make more priority information available for the other negotiator and therefore leaves less room for strategic misrepresentation, which could have a negative impact on different measures of negotiation performance.

4 Hypotheses

Although the performance awareness approach has the potential to outperform the priority awareness approach, we have to consider the risk explained by the regret theory, the cognitive load theory, and the strategic misrepresentation of information. We cannot tell the direction in which the dyads negotiating with available performance awareness will differ from dyads negotiating with available priority awareness in the different measures of negotiation performance. The most commonly used ways of measuring negotiation performance are economic in their nature. Besides measures that directly indicate how "good" a negotiation went, from an economical point of view, there are other measures that have an indirect influence on a negotiation or on future negotiations (section "5.3 Measures" explains all used measures in detail).

The joint outcome and the pareto efficiency are widely used in experimental negotiation studies (Thompson and Hastie 1990; Rangaswamy and Shell 1997; Hyder et al. 2000; Harinck and De Dreu 2004; Hindriks et al. 2011; Gettinger et al. 2012) and are both extensively documented by Tripp and Sondak (1992). The joint outcome is the sum of points both negotiators received for their agreement in the negotiation. The pareto efficiency is a calculated numerical value between 0 and 1, showing whether there are any agreements with better outcomes for at least one party without them being worse for the other party. Section "5.2 Material" holds the details about the point distribution.

H1: Dyads negotiating with available priority awareness differ in the economic outcome measures of the negotiation from dyads negotiating with available performance awareness.

The satisfaction with the negotiation is a strong indicator of the willingness for future negotiations with the same partner (Oliver et al. 1994). A profitable agreement for both parties loses its benefits when the parties were not satisfied and are not willing to participate in any future negotiations with each other. Closely related to satisfaction is the perceived likeability of the negotiation partner, which also indicates the willingness for future negotiations with the same partner (Lai et al. 2013).

H2: Dyads negotiating with available priority awareness differ in their satisfaction with the negotiation and their partner from dyads negotiating with available performance awareness.

The fairness of an agreement can be split in objective and subjective fairness. The objective fairness is sometimes referred to as contract balance (Foroughi 1998; Gettinger et al. 2012) and is a comparison of individual outcomes. The subjective fairness is the perceived fairness of the negotiators. Negotiators reciprocate unfairness (Ostrom 1998) and unfairness also leads to anger and spite which reduces the "frequency of mutually beneficial, negotiated agreements" (Pillutla and Murnighan 1996, p. 208). The vast majority of people tends to behave fairly and they also tend to have an inequality aversion (Fehr and Schmidt 1999).

H3: Dyads negotiating with available priority awareness differ in the fairness of the negotiation from dyads negotiating with available performance awareness.

Being seen as deceitful or being caught deceiving can lead to the loss of trust in a person or organization which is particularly harmful between organizations with repeated interactions (Grover 2005). In negotiations this can lead to a reduced acceptance of offers as well as costly punishment of the deceiver (Croson et al. 2003) and ultimately to less integrative agreements (Shapiro and Bies 1994) and thus less profit.

H4: Dyads negotiating with available priority awareness differ in their practiced and perceived deceitfulness during the negotiation from dyads negotiating with available performance awareness.

Although full, open, truthful exchange in negotiations exists (Raiffa et al. 2002; Herath et al. 2010), there seems to be a need for strategic misrepresentation in negotiations (Steinel and De Dreu 2004) in which the negotiators are able to withhold information. Besides the willingness to disclose more information, another question is about how much information one can remember about the negotiation partner. Remembering the priorities of one's negotiation partner helps in future negotiations with the same partner, as the priorities will not have changed much, and thus a faster negotiation with less preparation to get to know the other could be possible.

H5: Dyads negotiating with available priority awareness differ in how they deal with information for future negotiations from dyads negotiating with available performance awareness.

5 Method

5.1 Participants and Design

The sample consisted of 132 university students from different fields of study (100 female, 32 male, M_{age} = 24.01, SD_{age} = 3.70, age range: 19–36). They voluntarily took part in this experimental study for an hourly rate of 8 €. Sixty-six dyads were created by randomly assigning the roles of either a potential car buyer or seller. This resulted in 33 dyads per condition with either priority awareness and performance awareness. The distribution of gender in the dyads was controlled for by alternating the conditions for dyads consisting of female-female, male-male, and female-male.

5.2 Material

5.2.1 Payoff schedule. We modernized the payoff schedule of Thompson and Hastie (1990) for a car buying/selling scenario. In most experimental negotiation studies, the payoff schedule plays the central part. Participants are given a scenario and a specific role (e. g. a potential car buyer and a seller) and they are asked to negotiate over predefined issues with multiple options (Thompson and Hastie 1990; e.g. Hyder et al. 2000; Der Foo et al. 2004; Olekalns and Smith 2008; Van der Schalk et al. 2009). The payoff schedule is an individual table with the issues to be negotiated and their options, which are identical for both negotiators, as well as with the attached points for the options, which differ between the negotiators. The goal of each negotiator is to maximize the sum of his or her individual points. Table 2 holds a full overview of the used payoff schedule.

[INSERT TABLE 2 ABOUT HERE]

Of these eight issues with five options each, four issues were integrative: warranty, extras, financing and technology/audio could be profitably traded between the negotiators because they had a higher priority for one negotiator than for the other. Two issues were distributive: delivery date and price. Both negotiators wanted the exactly opposite option in these issues to gain the same amount of points. The last two issues were compatible: CO_2 emission and color were completely identical for both negotiators; they both prioritized the same option.

5.2.2 Bar charts. Bar charts are used worldwide from regular newspapers to business reports to scientific articles; they therefore seem to be a good choice for fostering priority and performance

awareness. Weber, Kersten and Hine (2006) have already discussed the potential of bar charts for fostering awareness of priorities. Rangaswamy and Shell (1997) used bar charts in their negotiation support system to visualize the own priorities of issues, but neither did they examine the specific effects of this visualization nor did they examine the effects of priority awareness. Bar charts have been shown to lead to shorter response times in information retrieval tasks (Quispel and Maes 2014) and also to more accurate judgment of proportions (Simkin and Hastie 1987) than other forms of visualization. Additionally they lead to better comparisons of values than tables (Jacobs 1994; Jacobs 1999).

The priorities of issues are visualized through the size of a bar in a bar chart: The higher the priority of an issue, the taller its bar. This is either visualized by an opaque bar (priority awareness condition) or indicated by a horizontal line (performance awareness condition). The priority of an issue – the size of its bar – is based on its option with the most points for the respective negotiator. Here we need to mention that only the modulus of the highest scoring option is important for the creation of priorities. For the issue "price", the buyer's loss of the highest scoring option "24,500 €, -6000 points" is higher than for the issue "delivery date" the gain of the highest scoring option "1 month, 2400 points". "Price" would therefore be of higher priority than "delivery date". Although omitted in many experimental negotiation studies, such negative point scores have a valid reason to exist because sometimes negotiators also have to agree on who loses less and not only who gains more.

Raiffa, Richardson and Metcalfe (2002, p. 214) use this approach of creating priorities by ranking the issues by the modulus of their highest scoring option in their evaluation of two-party integrative negotiations.

5.3 Measures

The measures used to test the stated hypotheses in its parts were either derived from the agreement made by each dyad or they were their answers to questions after the negotiation. The questions were four-point rating scales ranging from 1 "strongly disagree" to 4 "strongly agree". Some questions were inverted and subsequently recoded reversing the score in 4 "strongly disagree" to 1 "strongly agree". These questions are marked here with a minus sign "(-)". When not stated otherwise, we created mean scores for multiple questions of one measure. Other measures were also assessed but are not relevant to the stated hypotheses here.

5.3.1 Joint outcome. The options chosen for the agreement were logged in. On this basis, the points were calculated for each negotiator and summed to the joint outcome, which could possibly range from -3600 to 13200 points.

5.3.2 Pareto efficiency. The pareto efficiency was calculated according to the formula by Tripp and Sondak (1992); based on the agreement in each negotiation, the points of each negotiator and the calculation of all possible agreements and their outcomes (5^8 = 390625 possible agreements). A perfectly integrated agreement received a pareto efficiency of 1; an agreement in which no worse agreement for both parties existed received a pareto efficiency of 0. The used formula is similar to the one presented by Hyder et al. (2000):

$$\text{Pareto Efficiency of Joint Outcome } X = 1 - \left[\frac{N_b}{N_b + N_w}\right]$$

- $X =$ A negotiated joint outcome.
- $N_b =$ The number of possible agreements that were strictly better than joint outcome X for at least one party without being worse for the other party.
- $N_w =$ The number of possible agreements that were strictly worse than the joint outcome X for both parties.

5.3.3 Satisfaction. We asked two questions about the satisfaction with the negotiation: “I am satisfied with our negotiation” and “I am unsatisfied with our negotiation (-)” (r_S = .493, p < .001, n = 130).

5.3.4 Likeability. The likeability of the partner was assessed with the following two questions: “My negotiation partner was quite likeable” and “I do not want to negotiate with this partner in the future again (-)” (r_S = .456, p < .001, n = 130).

5.3.5 Objective fairness. For objective fairness, we divided the individual point difference between the negotiators of a dyad by the sum of the points of both negotiators: We divided the contract balance by the joint outcome. “Contract balance is not a standardized measure of negotiation fairness” as

Goh, Teo, Wu and Wei (2000) conclude. This is the reason why we calculated the percental difference between the individual outcomes for each negotiation dyad, making them comparable.

$$\text{Objective Fairness of Agreement } A = \left[\frac{|Y_B - Y_S|}{X}\right]$$

- $A =$ A negotiated agreement with its individual and joint outcomes.
- $Y_B =$ The individual outcome of negotiator one (the buyer).
- $Y_S =$ The individual outcome of negotiator two (the seller).
- $X =$ A negotiated joint outcome.

In this study, the objective fairness could hypothetically range from -250% to 280,$\overline{3}$%. Assuming the buyer achieved a maximum loss of -7800 points and the seller a win of 7200 points, this would create a joint outcome of -600 points. The difference between both would amount to 15000 points, which would be 25 times the joint outcome of -600 points. The minus-sign of the percentage is only an indicator for an agreement which had a loss-making joint outcome. This measure is only applicable for non-zero joint outcomes.

5.3.6 Subjective fairness. For subjective fairness, we asked two questions about the perceived fairness of the agreement: "I believe that the result of our negotiation is fair" and "Our agreement in the negotiation is unfair (-)" ($r_S = .665$, $p < .001$, $n = 130$).

5.3.7 Personal deceitfulness. "Honesty is the absence of deception" (Cramton and Dees 1993, p. 3) and therefore deception can be seen as an inverse of honesty. To obtain an indicator about one's own deceitfulness during the negotiation, we asked these questions: "I was open and truthful to my negotiation partner (-)" and "I held back information to get a better result for myself" ($r_S = .517$, $p < .001$, $n = 130$).

5.3.8 Perceived deceitfulness. To obtain an indicator about the perception of their partner being deceitful during the negotiation, we asked these questions: "My negotiation partner was honest with me (-)" and "My negotiation partner lied to me" ($r_S = .605$, $p < .001$, $n = 130$).

5.3.9 Information disclosure. To assess how willing the negotiators were to disclose more information – such as their full payoff schedule – in future studies, we asked the following two questions: "I would not have wanted my negotiation partner to see my point scores in his/her table" and "It would not have bothered me if my negotiation partner would have seen my point scores in his/her table (-)" (r_S = .652, p < .001, n = 130).

5.3.10 Information memory. We used a graphical test to assess how much the negotiators remembered with respect to the priorities of the other after the negotiation was done. The negotiators had to drag bars from the upper half of the screen, representing the priorities of issues of their partner, to the lower half of the screen, dropping them into placeholders next to their own bars, representing their own priorities of issues. For each issue, we calculated a deviation score between every set priority and its true priority and summed them up for both negotiators. The deviation score could range from 0 – perfect remembering of the priorities of the partner – to 48.

5.4 Procedure

The whole experiment took place within an experimental negotiation support system created specifically to compare the effects of priority awareness and performance awareness. The duration was approximately one hour. The experiment was broadly divided in three phases: pre-negotiation (working alone), negotiation (working together) and post-negotiation phase (working alone).

5.4.1 Pre-negotiation phase. The participants were greeted and briefed shortly about the procedure of the experiment as follows:

They would work alone in separate rooms. Everything would take place on the computer in front of them and all instructions would be presented to them on the monitor. They would first work alone until the negotiation phase when they would have to put on a headset for the negotiation. After the negotiation phase, both negotiators would once again work separately.

After the participants filled out a declaration of consent about the data that would be gathered about them and how it would be used, they were informed that they could at any time abort the experiment and retract their data without incurring any drawbacks; they began with a questionnaire about

personal data, such as the field of study, gender, age, prior knowledge, and frequency of usage of computers/tables/diagrams and acquaintance with the other negotiator.

Next, the individual role and the negotiation scenario were described for the first time (here exemplary of the seller):

> *You are the head of a big automaker and want to sell a fleet of cars. You are negotiating with the head of a big insurance company. You have to agree on 8 issues: financing, CO_2 emission, warranty, delivery date, extras, technology/audio, price and color. Every issue has 5 options with different point scores corresponding to the wishes of your role. You are negotiating for points: Your goal is to maximize your own points!*

After this introduction, a preview of the experimental negotiation support system was presented. It looked nearly identical to the screenshot of the experimental negotiation support system in the priority awareness condition (Fig. 1) but only showed the individual priorities in the upper half of the screen. The only instructions here were:

> *You cannot do anything here yet! This is supposed to give you a first impression of the negotiation interface. To continue, you may click on "Forward" in one minute.*

To engage the participants with the bar chart, we presented them with a task on the next screen:

> *Put the issues in the order IMPORTANT → UNIMPORTANT. Drag the individual bars into the lower diagram and begin left with the most important issue, the one with which you can win or lose the most points. Click on "Forward" when you are finished. Errors will be orange-rimmed and you can correct them. You will have 5 minutes' time for this.*

There was no further information given on behalf of the bar chart. The words "priority" and "performance" never once appeared.

5.4.2 Negotiation phase. After this preview, the individual role and the negotiation scenario were described again with further instructions on the following negotiation interface:

Both participants could independently click on options in the lower half of the screen, which both would then see as marked. They could also freely change this marking, independent of who set it. The marking of options would be there to help them during the negotiation but also to save their final agreement. There were three possibilities to finish the negotiation, namely, (1) finishing by clicking on "Agreement", (2) aborting by clicking on "Abort" when it becomes clear that they would not arrive at an

agreement, (3) negotiating longer than 35 minutes and being automatically forwarded to the next screen where they would be asked whether they agreed, saving the last marked options as the agreement.

There was one condition-specific piece of information here, telling the participants about the layout of the negotiation interface, because the preview only showed their own priorities and did not include those of their partner:

> *In the upper diagram you can see how important the single issues are, for you and your partner. The marking of options does not change the diagram.* Priority awareness condition.
>
> *In the upper diagram you can see how important the single issues and options are, for you and your partner. The marking of options changes the diagram.* Performance awareness condition.

Exemplary for the seller, Figures 1 and 2 show a screenshot of the negotiation phase. There were no meaningful differences between the buyer and the seller besides their role description and their priorities of issues. The negotiators used their headset to communicate over an audio-only Skype connection (see Bazerman et al. 2000 for the benefits of an audio-only communication in a negotiation), which only lasted for the duration of the negotiation phase. The participants were free to carry out the negotiation and communicate as they wished. The negotiation was completely unscripted and there were no constraints on what the negotiators could talk about.

To test the effects of priority awareness and performance awareness, the negotiators saw a bar chart with different properties in the upper half of the screen and their own payoff schedule with clickable radio buttons in the lower half of the screen.

The negotiators in the priority awareness condition (Fig. 1) were made aware only of the priorities of issues. The bars here were completely opaque and non-interactive. The bar chart visualized their own priorities of issues as well as those of the other negotiator.

The negotiators in the performance awareness condition (Fig. 2) were also made aware of their current performance besides the priorities of the issues. The bars here were at first only indicated by horizontal lines where the outermost horizontal lines represented the priorities of options. The moment one negotiator marked an option of an issue, the bars of this issue filled up to specific horizontal lines. The degree of fill level corresponded to the point scores attached to this option for each individual negotiator. For example: The option “6%” of the issue “financing” was marked (see Fig. 2) and therefore the size of the red bar corresponded to the point score of this option of the seller. The size of the blue bar

corresponded to the point score for this option for the buyer. Besides this difference in the upper half of the screen, there were no differences between the conditions.

The payoff schedule in the lower half of the screen was dependent on the role as buyer or seller. Both parties only saw their own point scores for the common set of options of each issue. Both could mark or change the mark of the options which had different point scores attached to them. The options marked were then logged in by the negotiation support system when the negotiators clicked on "Agreement".

[INSERT FIGURES 1 & 2 ABOUT HERE]

5.4.3 Post-negotiation phase. After the negotiation, the participants worked alone again, and the information memory was tested. The instructions here were:

> *Assign the points of your partner to the correct issues. Drag the bars of your partner (above) next to your bars (below) in the diagram. You can freely move the bars of your partner. There is no error message! Take your time and click only then on "Forward" when you believe that the points of your partner have been assigned to the correct issues.*

Finally, the participants were asked to answer questions on their satisfaction with the negotiation, the likeability of their partner, their perceived fairness of the agreement, their own honesty, and the honesty of their partner. Additionally, they were asked about their willingness to disclose more information in a future negotiation.

Afterwards, the participants were paid and shortly debriefed.

6 Results

For the analyses we used a Wilcoxon rank-sum test or, where the normality assumption was not violated, a t-Test. There were no meaningful differences between the conditions in the control measures age, familiarity with the partner, computer abilities, effortlessness, and frequency of using tables or diagrams (all Ws > 2077 with N = 132, all ps > .165). Both conditions can be seen as identical and all differences in the measures of negotiation performance can be ascribed to the condition. All analyses were conducted on the aggregated data on the level of dyads because the individuals were not independent of each other (Cress 2008). There were no impasses and all dyads achieved a positive joint outcome.

Table 3 holds an overview of the correlations between the used measures of negotiation performance. All measures forming one hypothesis are significantly correlated with each other.

[INSERT TABLE 3 ABOUT HERE]

H1 disconfirmed: Both conditions did not differ in the agreed joint outcome (M_{PriA} = 10055, SD_{PriA} = 2428, M_{PerA} = 9055, SD_{PerA} = 2796, p = .262) and the achieved pareto efficiency (M_{PriA} = 0.96, SD_{PriA} = 0.10, M_{PerA} = 0.89, SD_{PerA} = 0.26, p = .228).

H2 confirmed: The negotiation dyads with priority awareness (M = 3.23, SD = 0.40) were more satisfied with the negotiation than the dyads with performance awareness (M = 2.99, SD = 0.44, W = 690, p = .031, r = -.28) and they also found their negotiation partner more likeable (M_{PriA} = 3.49, SD_{PriA} = 0.40, M_{PerA} = 3.18, SD_{PerA} = 0.42, W = 749, p = .003, r = -.37)

H3 confirmed: The negotiation dyads with priority awareness (M = 3.43, SD = 0.41) found their agreement subjectively fairer than the dyads with performance awareness (M = 3.20, SD = 0.40, W = 702.5, p = .020, r = -.41). Objectively, there was no difference in the fairness of the agreement between the conditions (M_{PriA} = 16.5%, SD_{PriA} = 22.0%, M_{PerA} = 22.6%, SD_{PerA} = 30.4%, W = 453, p = .237)

H4 confirmed: The negotiation dyads with priority awareness (M = 1.51, SD = 0.41) not only said that they were less deceitful in the negotiation than the dyads with performance awareness (M = 1.88, SD = 0.43, W = 283, p = .001, r = -.41), and they also perceived their negotiation partner as less deceitful (M_{PriA} = 1.59, SD_{PriA} = 0.40, M_{ProA} = 1.80, SD_{ProA} = 0.36, $t(63)$ = -2.15, p = .036, d = .53).

H5 confirmed: The negotiation dyads with priority awareness (M = 2.27, SD = 0.63) were more willing to also present their full payoff schedule to their partner in future negotiations than the dyads with performance awareness (M = 2.58, SD = 0.55, $t(63)$ = -2.13, p = .037, d = .53). In replicating the priorities from the other party after the negotiation, the negotiation dyads with priority awareness (M = 25.76, SD = 5.38) remembered fewer correct priorities of the other party than the dyads with performance awareness (M = 20.18, SD = 7.49, $t(64)$ = 3.48 , $p < .001$, d = .86).

7 Discussion

A successful negotiation strongly relies on the negotiators' awareness of each other's priorities. Being aware of which issues could be traded off in a beneficial way leads to an integrative negotiation. We compared two different kinds of awareness and their influence on different measures of negotiation

performance in an experimental negotiation support system: (1) priority awareness, tacitly facilitated with non-interactive bar charts and (2) performance awareness, tacitly facilitated with interactive bar charts.

Through its interactivity, the performance awareness approach could have possibly facilitated the steps needed to create awareness (see Table 1) and thus diminish the fixed-sum-error. Additionally, it could have possibly created another quality of priority awareness on the level of options as well as issues, which could have reduced the incompatibility error. Making a more extensive use of information and communications technologies, interactive possibilities did not, however, improve the negotiation performance; on the contrary, it even had detrimental effects: There was no difference in the joint outcome or in the pareto efficiency – being indicators for the fixed-sum-error – and ultimately no difference in the commitment of the incompatibility error between dyads negotiating with priority awareness or performance awareness. Dyads negotiating with performance awareness were less satisfied with their negotiation, found their partner less likable, found their agreement less fair – although there was no objective difference in fairness – were more deceitful in the negotiation, and also thought their partner was more deceitful. There were two results in which dyads negotiating with performance awareness had a higher score than those negotiating with priority awareness. On the one hand, they could remember the priorities of their partner better and, on the other hand, they were less willing to disclose even more information in form of their payoff schedule.

Although the performance awareness approach had great potential for being superior to the priority awareness approach, it was mostly inferior to it. An explanation of why there was no difference in the joint outcome and the pareto efficiency between the conditions lies in the higher complexity of the interactive bar charts and their greater need for cognitive resources (Chandler and Sweller 1991). Further, although performance awareness created awareness of the priorities of options inside issues, making the options discoverable – which both negotiators unanimously preferred – and thus potentially circumventing the incompatibility error, we believe that the negotiators were too busy handling the higher complexity that accompanied the introduced interactivity to have also noticed these kinds of options. The interactivity may have led to too much awareness and too much information to process at once. This is also in line with Schmutz et al. (2009) where higher complexity led likewise to less satisfaction with a computer system.

The regret theory (Loomes and Sugden 1982; Bell 1982) holds an answer to why performance awareness had these adverse effects on satisfaction with the negotiation, likeability of the partner, the subjective fairness of the agreement, as well as the personal and the perceived deceptiveness. These five concepts were significantly correlated with each other, indicating that these are interrelated concepts which might have been influenced at once. Performance awareness not only showed the current

performance in the negotiation, but also made the transition from a previous state more salient: The negotiators were made aware of what they have lost in the transition of one offer to another and what the other negotiator had received in return, which may not have been a fair trade. Also, the goal of the negotiation was to maximize the individual points – to get the bars to an optimal size. Being made aware of a deviation from this goal could have also led to frustration.

As for the higher deceptiveness and the perceived deceptiveness of the partner in the performance awareness condition, there seems to be a need for strategic misrepresentation (Steinel and De Dreu 2004), which becomes more visible, the less information there is that the negotiators can hide. In a scenario in which each negotiator is made aware of the other's priorities of issues and options, complete rational and fair negotiators would achieve a perfect integrative agreement with the highest possible joint outcome and perfect pareto efficiency. But humans are not completely rational and fair (f. e. Henrich et al. 2001). The highest individual outcome is only possible at the cost of the negotiation partner's individual outcome. In a scenario in which more detailed information about one's priorities is available, the only possible way to gain a higher individual outcome is to be deceptive. But because the priority information is available, this deception is easier to see through.

The dyads with priority awareness were more willing to even share their individual payoff schedule. Dyads with performance awareness already had more awareness and they were less convinced of sharing even more information. The correlations with the joint outcome and pareto efficiency indicate that a higher willingness to share even more information was connected to a better economical negotiation outcome. It seems as if awareness of negotiation relevant information has its benefits and people assume that more would be better, but when they have more awareness of negotiation-relevant information, they change their mind. This again is an indicator of the need for strategic misrepresentation of information because people who have less opportunity to deceive are also less willing to share even more information.

The individual payoff schedule is the basis of every complex negotiation. It attaches measureable values to options and creates priorities for issues. Otherwise, negotiators would have to rely on fast assumptions of which issue or option is more or less important to them. Giving away the individual payoff schedule is a full disclosure of the key information in a negotiation. Our results show that negotiators would prefer a partial, open, truthful exchange over a full, open, truthful exchange (Raiffa et al. 2002).

After the negotiation, the dyads with performance awareness knew more about the priorities of their negotiation partner than the dyads with priority awareness. Remembering the priorities of the partner after the negotiation is useful for recurring negotiations between the same parties as this would save time

in coming to terms with the others' priorities. Other studies on awareness centered on learning and problem solving. In these studies, the extent of the knowledge that one group member gained about the others was assessed (e. g. Engelmann et al. 2009). In such a context, added interactivity and more detailed awareness would be more useful since it has been clearly shown to lead to more engagement with the information of the other and better retention.

A shortcoming of the present study is the mentioned full, open, truthful, exchange of information that we granted the negotiators. We did so to be able to compare the effectiveness of the two different awareness conditions, which could not have been properly done without giving away all priority information about issues (and options). Through a full, open, truthful exchange in a negotiation, the negotiators may "gain clarity, simplicity and crispness of definition" (Raiffa et al. 2002, p. 87) about their negotiation which also is the case in reality (Raiffa et al. 2002; Herath et al. 2010). A partial, open, truthful exchange is also the case in reality: Not all information is exchanged open and truthfully. Sometimes a full, open, truthful exchange is not possible with a partner who cannot be trusted and sometimes negotiations start out as partially open and truthful but then change to fully open and truthful, understanding its benefits (Raiffa et al. 2002).

Interactive visualizations are broadly used in economical decision making (Dilla et al. 2010). Their goal is to interactively visualize different key performance indicators to help decision-makers or negotiators to come to a beneficial decision and in the context of a negotiation, a beneficial agreement. This study leads to the question how many interactive computer-supported environments could work as well as non-interactive ones which are implemented in a faster, cheaper, and simpler way. It is not a question of adding more interactive features but removing some. Removing features, reducing the amount of information, and limiting the amount of possible interaction could lead to the same or even better outcomes. Future studies will have to focus on simpler ways of creating a limited amount of awareness and also on a partial, open, truthful exchange of information, answering the question: How much voluntarily given awareness about one's own information is enough to improve negotiation performance?

8.1 Conclusion

There seems to be the phenomenon of too much awareness. Performance awareness makes the current state of the negotiation salient to the negotiators and can clearly help facilitate decision making processes in a computer-supported environment. It unfortunately also leads to simply too much information to handle at once efficiently, to feelings of regret, and prevents the use of strategic misrepresentation. These effects have a negative influence on satisfaction, fairness, and honesty. Such an awareness approach

comes with its share of disadvantages that does not justify the additional amount of time and resources needed to create and maintain it. Non-interactive awareness approaches are easier and cheaper to create and maintain and optimally do not take up much mental effort in using them, do not leave the negotiators with feelings of regret, and should still leave the negotiators some room for strategic misrepresentation of information.

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Figure 1 Click here to download colour figure 2016-07-07_Fig_1.docx

Fig 1. Control condition with priority awareness (as seen by the seller): Non-interactive bar charts that do not change by agreeing on one option for each issue

Figure 2 Click here to download colour figure 2016-07-07_Fig_2.docx

Fig 2. Experimental condition with performance awareness (as seen by the seller): Interactive bar charts which fill up depending on the one agreed option for each issue

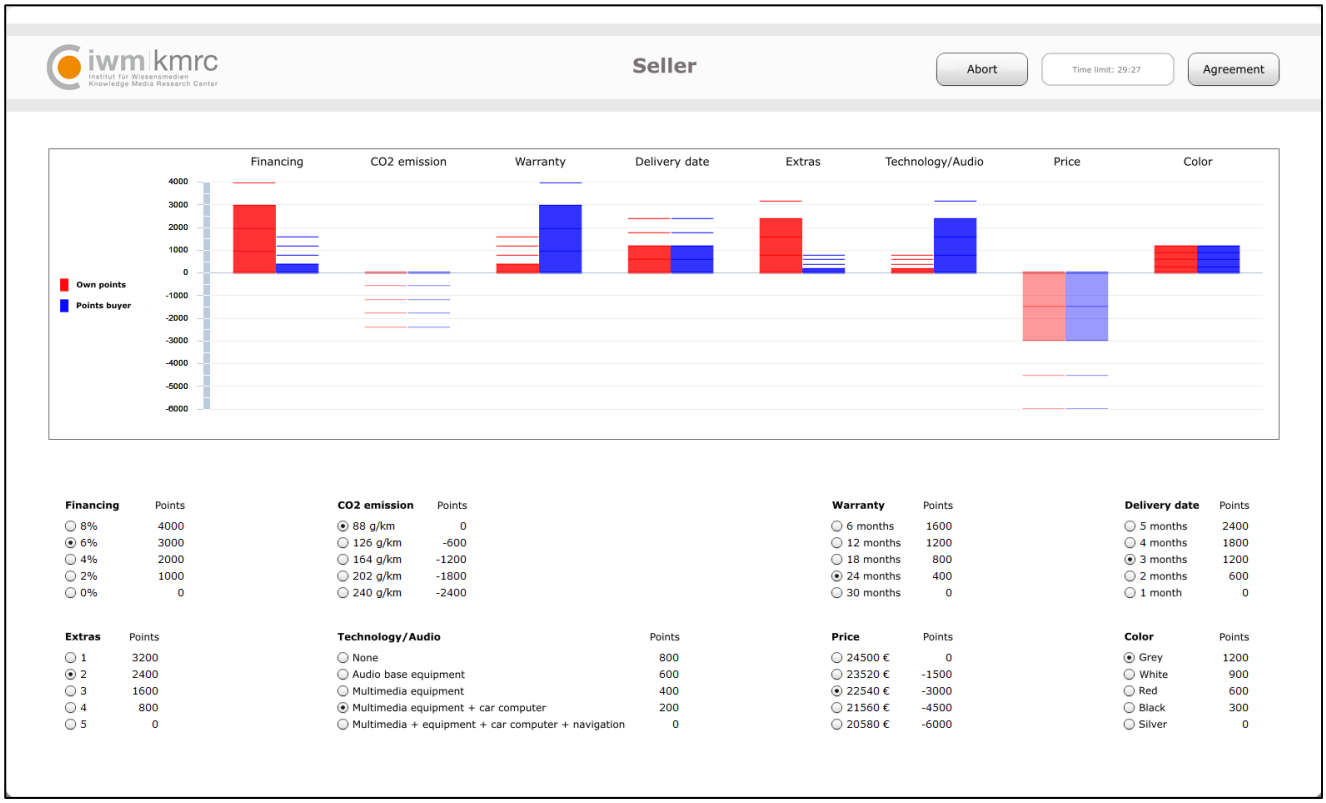

Table 1. Psychological Steps Involved in the Effectiveness of Methods of Creating Awareness

Step	Description	Example for this Study
1 Perception	The method of creating awareness have to be perceived by a person	The attention of the person has to be caught in some way by the bar charts.
2 Understanding	The person has to understand what the content of the perceived method is	It is about the differences in priorities of issues (and, additionally, options for performance awareness)
3 Interpretation	The person has to interpret the content in the context of the situation	Understanding what the differences in priorities mean for the negotiation
4 Behavior	The person has to change his/her behavior based on the interpretation	Engaging in integrative negotiation

Table 2. Overview of Payoff Schedule with all Issues and their Options with Attached Individual Point Scores

Financing	Points Buyer	Points Seller	**CO_2 Emission**	Points Buyer	Points Seller	**Warranty**	Points Buyer	Points Seller	**Delivery Date**	Points Buyer	Points Seller
8 %	1600	4000	88 g/km	0	0	6 months	0	1600	5 months	0	2400
6 %	1200	3000	126 g/km	-600	-600	12 months	1000	1200	4 months	600	1800
4 %	800	2000	164 g/km	-1200	-1200	18 months	2000	800	3 months	1200	1200
2 %	400	1000	202 g/km	-1800	-1800	24 months	3000	400	2 months	1800	600
0 %	0	0	240 g/km	-2400	-2400	30 months	4000	0	1 month	2400	0
Extras	Points Buyer	Points Seller	**Technology/Audio**	Points Buyer	Points Seller	**Price**	Points Buyer	Points Seller	**Color**	Points Buyer	Points Seller
1	0	3200	None	0	800	24.500 €	-6000	0	Grey	1200	1200
2	200	2400	Audio base equipment	800	600	23.520 €	-4500	-1500	White	900	900
3	400	1600	Multimedia equipment	1600	400	22.540 €	-3000	-3000	Red	600	600
4	600	800	Multimedia equipment + car computer	2400	200	21.560 €	-1500	-4500	Black	300	300
5	800	0	Multimedia equipment + car computer + navigation	3200	0	20.580 €	0	-6000	Silver	0	0

The buyer and the seller could only see their own point scores during the negotiation, independent of the condition. There were no restrictions made on the communication of the negotiators, including the sharing of any of this information.

Table 3. Overall Correlations between the Used Measures of Negotiation Performance

	Joint outcome	**Pareto efficiency**	**Satisfaction**	**Likeability**	**Objective fairness**	**Subjective fairness**	**Personal deceitfulness**	**Perceived deceitfulness**	**Information disclosure**	**Information memory**
Joint outcome		0.996***	0.060	0.019	-0.175	0.018	0.085	0.032	0.319**	-0.009
Pareto efficiency	0.996***		0.069	0.030	-0.195	0.031	0.074	0.042	0.324**	-0.029
Satisfaction	0.060	0.069		0.493***	-0.212	0.660***	-0.480***	-0.473***	-0.137	-0.047
Likeability	0.019	0.030	0.493***		-0.199	0.566***	-0.547***	-0.567***	-0.330**	-0.112
Objective fairness	-0.175	-0.195	-0.212	-0.199		-0.319**	0.265*	0.255*	0.027	0.350**
Subjective fairness	0.018	0.031	0.660***	0.566***	-0.319**		-0.604***	-0.602***	-0.282*	-0.211
Personal deceitfulness	0.085	0.074	-0.480***	-0.547***	0.265*	-0.604***		0.701***	0.482***	0.216
Perceived deceitfulness	0.032	0.042	-0.473***	-0.567***	0.255*	-0.602***	0.701***		0.471***	0.076
Information disclosure	0.319**	0.324**	-0.137	-0.330**	0.027	-0.282*	0.482***	0.471***		0.298*
Information memory	-0.009	-0.029	-0.047	-0.112	0.350**	-0.211	0.216	0.076	0.298*	

Spearman's correlation with pairwise-deletion. *$p < .05$, **$p < .01$, ***$p < .001$.

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Abstract: Computer-supported negotiations are gaining traction in business interactions. Previous studies have demonstrated mixed findings on how negotiators' personality traits influence the individual outcomes. Research has not investigated the HEXACO so far and has not tested for the interdependent effects of the negotiators' personalities. We use the actor-partner interdependence model to test the influence of different personality traits, figural intelligence, and social value orientation on the individual outcomes in computer-supported negotiations. Two conditions differing in the interactive capabilities and amount of information of the used negotiation support system were implemented. One hundred thirty-two participants in 66 dyads negotiated in their roles as seller or buyer. Analyses show that a negotiator's own personality traits, figural intelligence, and social value orientation have no influence on his or her own individual outcome. However, individuals' outcomes are positively affected by their partners' lower emotionality - lower dependence and sentimentality - their higher social value orientation and higher figural intelligence. The characteristics of the opposing partner are crucial for one's own individual outcome: emotional stability, a distinct ability to interpret figures, and a more prosocial attitude are important for a beneficial agreement. Possible explanations for these results are discussed and the shortcomings of this study addressed.

HEXACO Personality Traits That Shape the Individual Outcome in Computer-Supported Negotiations

Abstract

Computer-supported negotiations are gaining traction in business interactions. Previous studies have demonstrated mixed findings on how negotiators' personality traits influence the individual outcomes. Research has not investigated the HEXACO so far and has not tested for the interdependent effects of the negotiators' personalities. We use the actor-partner interdependence model to test the influence of different personality traits, figural intelligence, and social value orientation on the individual outcomes in computer-supported negotiations. Two conditions differing in the interactive capabilities and amount of information of the used negotiation support system were implemented. One hundred thirty-two participants in 66 dyads negotiated in their roles as seller or buyer. Analyses show that a negotiator's own personality traits, figural intelligence, and social value orientation have no influence on his or her own individual outcome. However, individuals' outcomes are positively affected by their partners' lower emotionality – lower dependence and sentimentality – their higher social value orientation and higher figural intelligence. The characteristics of the opposing partner are crucial for one's own individual outcome: emotional stability, a distinct ability to interpret figures, and a more prosocial attitude are important for a beneficial agreement. Possible explanations for these results are discussed and the shortcomings of this study addressed.

Keywords: HEXACO; personality; actor-partner interdependence model; individual outcome; negotiation support system; negotiation; figural intelligence; social value orientation

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1 Introduction

Regardless of the subject of a negotiation –be it over a new car, over the amount of wages, over a multimillion business contract – every negotiation party has the clear goal of achieving a beneficial agreement and maximizing its individual outcome. Partners enter a negotiation with their individual personality which might not only shape their own outcome but might also do so for the outcome of the partner. Previous studies concerning personality – as measured with the "big five" – and individual negotiation outcomes have shown inconsistent results. They also did not examine the influence within a computer-supported environment and did not take the mutual influence of the partners' personality into account.

Barry and Friedman (1998) found that extraversion and agreeableness had no influence on individual outcomes, but they did find that higher conscientiousness improved individual outcomes. Liu, Friedman an Chi (2005) also found no effects of extraversion but of one of agreeableness: the more agreeable a negotiator, the lower his or her individual outcome. Ma and Jaeger (2005) found that higher extraversion was associated with a higher individual outcome as was openness to experience. Neuroticism had no influence on the individual outcome here. The study by Foo, Elfenbein, Tan and Aik (2004) found a positive influence of neuroticism on the individual outcome.

Business to business negotiations are now nearly not possible to imagine without some kind of computer-support. Specific negotiation support systems can facilitate negotiations by making relevant information available (Kolodziej, Hesse, & Engelmann, 2015; Rangaswamy & Shell, 1997; Schoop et al., 2014; Weber, Kersten, & Hine, 2006), but such computer-support can

also foster private self-awareness which leads to a focus on personal perceptions and thoughts (Sassenberg, Boos, & Rabung, 2005) and thus might have an influence on the effects of personality in computer-supported negotiations.

Only recently the focus of negotiation studies shifted to the interindividual influences using the actor-partner interdependence model (APIM; Kenny, Kashy, & Cook, 2006) as the appropriate statistical method for the analysis (Turel, 2010).

With this experimental study, we are seeking to shed some light on the inconsistent findings of different personality traits on the individual outcome and find mutual effects in computer-supported negotiations. Additionally, we are looking for the effects of figural intelligence and social value orientation, which play an important a role in this setup. To our knowledge, the HEXACO personality scales (Ashton & Lee, 2009) and the actor-partner interdependence model (Kenny et al., 2006) have never before been applied in computer-supported negotiations.

2 The HEXACO Personality Inventory

The freely available HEXACO scales (Ashton & Lee, 2009) are the most up to date model of personality structure. They are still fairly new in the scientific community at large and the negotiation community specifically.

They are nearly identical to the widely known big five: extraversion, agreeableness, conscientiousness, openness to experience and neuroticism (f. e. NEO-PI-3; McCrae, Costa, & Martin, 2005). The HEXACO consists of six scales: extraversion, agreeableness, conscientiousness, openness to experience and – instead of neuroticism – honesty-humility and emotionality. Every scale has four subscales.

Extensive and precise descriptions of the scales and subscales can be found on the official HEXACO website (Ashton & Lee, 2016). We will briefly describe relevant scales and subscales in the Results section.

3 Computer-Supported Negotiations

Decision makers are increasingly relying on negotiation support systems which facilitate communication and coordination of individual activities (Kersten & Lai, 2007). Multiple negotiation support systems exist in real life negotiation settings such as Zopaf (Andinian Inc., 2015) or Smartsettle (iCan Systems Inc., 2015) and in experimental negotiation settings such as Inspire (Kersten & Noronha, 1999) or Negoisst (Schoop, Jertila, & List, 2003), which structure the negotiation and create awareness for crucial information.

Multiple studies conducted on different negotiation support systems have confirmed the utility of these systems and their positive influence on different negotiation outcomes (Kolodziej et al., 2015; Rangaswamy & Shell, 1997; Schoop et al., 2014; Weber et al., 2006).

These studies used negotiation support systems with a different number of features having different interactive capabilities and different amounts of available information.

4 Research Questions

To test the interdependent effects of the HEXACO personality traits, we used an experimental negotiation support system with a graphical decision aid (Gettinger & Koeszegi, 2012). As part of a larger study described elsewhere, we compared two conditions differing in the interactive capability and the amount of available information of the negotiation support system. We used a scenario in which the roles of a buyer and a seller negotiate in dyads over a vehicle fleet.

Besides the HEXACO scales, we assessed other characteristics which could have an interindividual influence on the individual outcomes and which could interact with the two experimental conditions. Considering the heterogeneity of previous findings, we will not formulate specific hypotheses but rather several research questions:

How does personality affect the individual outcomes? (RQ1)

As mentioned above, the findings to date on the influence of personality on a particular way of measuring individual outcome have been ambiguous and the interindividual differences have not been taken into account. Also, the HEXACO scales have not been used in a negotiation study before. We are seeking to find an answer to this.

How does the individual social value orientation affect the individual outcomes? (RQ2)

The social value orientation is a set of "motivations that underlie interdependent decision behavior" (Murphy, Ackerman, & Handgraaf, 2011, p. 711) and is a measure of the magnitude of the concern people have for others (Murphy et al., 2011). It already has a big influence on the joint outcome in negotiations (De Dreu, Weingart, & Kwon, 2000). The interindividual effects on the individual outcome have not been tested until now.

How does figural intelligence affect the individual outcomes? (RQ3)

As negotiation support systems generally rely on graphical decision aids, there is a strong connection to one's general ability to understand and process graphically represented information. How this influences the individual outcome has not been tested before.

5 Method

The method section is held short because the specificities of the graphical decision aid, the different possibility of interaction, and the different amount of information, as well as their

influence on different dyadic measures of negotiation performance are documented in another publication elsewhere. These do not fit the scope of this journal or the topic of this paper. Additionally, the two conditions had no influence on the reported results; therefore, we do not differentiate any further between them.

5.1 Measures

There are multiple hard and soft skills needed to perform a financially successful negotiation (e.g. De Dreu, Beersma, Steinel, & van Kleef, 2007; Thompson, Wang, & Gunia, 2010); however, the relevant ones in our study – which uses a negotiation support systems with a graphical decision aid – are figural intelligence and social value orientation. Other measures were also assessed but are not relevant to the stated research questions.

5.1.1 Individual outcome. On the basis of the chosen options for the agreement in a negotiation, individual points were given depending on the role's payoff schedule (see Table 1 and the "Material" subsection). The individual points could possibly range from -8400 to 13200.

5.1.2 HEXACO. The six scales and their four subscales each were found in lexical studies of personality structure and have been cross-culturally replicated (Ashton & Lee, 2007). The internal consistency for the scales and subscales ranges from $\alpha = .75$ to $\alpha = .92$ (Lee & Ashton, 2004). The convergent validity was tested for with five scales from the International Personality Item Pool (Goldberg, 1999) and the Primary Psychopathy scale (Levenson, Kiehl, & Fitzpatrick, 1995). It ranged from $\alpha = .80$ to $\alpha = .90$ (Ashton & Lee, 2007). The HEXACO-60 consists of 60 items, 10 per scale and within these, two to three per subscale. The items are five-

point rated ranging from 1 “strongly disagree” to 5 “strongly agree”. Some items were reversed where a score of 1 resembles “strongly agree” and 5 “strongly disagree”.

5.1.3 Social value orientation. The SVO slider measure by Murphy et al. (2011) consists of six items in which one of nine predefined resource allocations has to be chosen; for example, the decision maker can chose a fictitious value of 85 for him or herself and for another person a value between 15 and 85. The SVO slider measure has a test-retest reliability of r = .92 and a predictive validity tested against the binary choices in a Prisoner’s Dilemma game of r_{pb} = .24 (Murphy & Ackermann, 2012). A higher value represents a more prosocial attitude.

5.1.4 Figural intelligence. We used the figure selection task form A of the intelligence structure test 2000 R (Liepmann, Beauducel, Brocke, & Amthauer, 2007) to assess the kind of figural intelligence suitable for our study and examined its influence on the individual outcomes. Because we digitally adapted the analog paper and pencil test and did not strictly control the participants as needed for an intelligence test, we only used the raw points ranging from 0 to a maximum sum of 20. The internal consistency of the figure selection task form A is α = .77 and the split-half reliability is r = .80 (Liepmann et al., 2007).

5.2 Material and Design

For our car buying/selling negotiation scenario, we modernized the payoff schedule by Thompson and Hastie (1990). The payoff schedule holds the predefined issues and options for both negotiators in which individual points are attached that are only visible to the specific role.

The goal of each negotiator is to maximize the sum of his or her individual points. Table 1 holds a full overview of the used payoff schedule.

Table 1

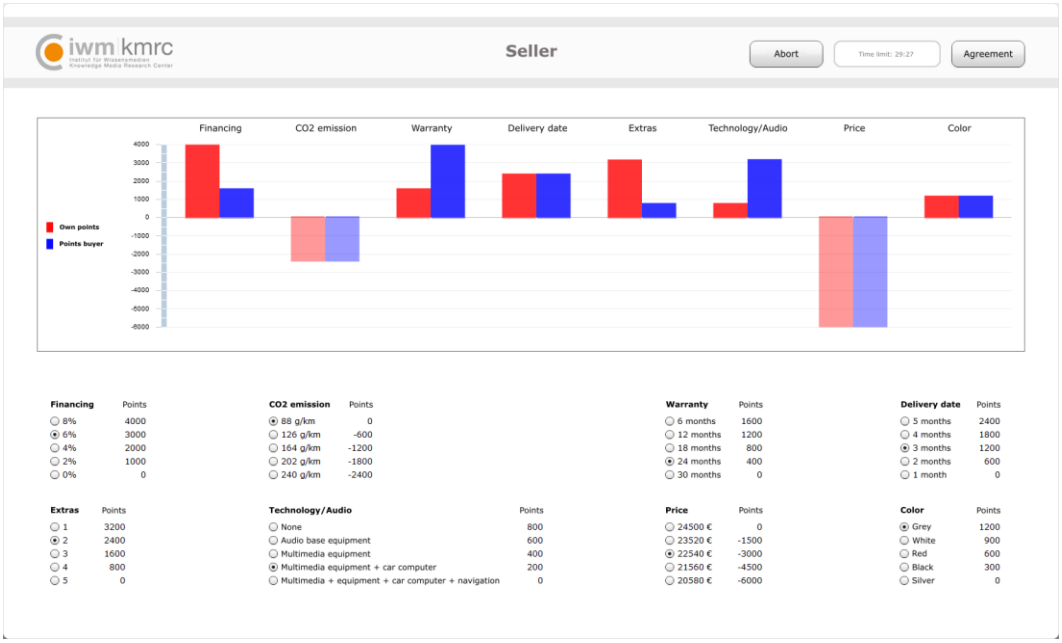
Overview Payoff Schedule With all Issues and Their Options With Attached Individual Point Scores

Financing	Points Buyer	Points Seller	**CO² Emission**	Points Buyer	Points Seller	**Warranty**	Points Buyer	Points Seller	**Delivery Date**	Points Buyer	Points Seller
8 %	1600	4000	88 g/km	0	0	6 months	0	1600	5 months	0	2400
6 %	1200	3000	126 g/km	-600	-600	12 months	1000	1200	4 months	600	1800
4 %	800	2000	164 g/km	-1200	-1200	18 months	2000	800	3 months	1200	1200
2 %	400	1000	202 g/km	-1800	-1800	24 months	3000	400	2 months	1800	600
0 %	0	0	240 g/km	-2400	-2400	30 months	4000	0	1 month	2400	0
Extras	Points Buyer	Points Seller	**Technology/Audio**	Points Buyer	Points Seller	**Price**	Points Buyer	Points Seller	**Color**	Points Buyer	Points Seller
1	0	3200	None	0	800	24.500 €	-6000	0	Grey	1200	1200
2	200	2400	Audio base equipment	800	600	23.520 €	-4500	-1500	White	900	900
3	400	1600	Multimedia equipment	1600	400	22.540 €	-3000	-3000	Red	600	600
4	600	800	Multimedia equipment + car computer	2400	200	21.560 €	-1500	-4500	Black	300	300
5	800	0	Multimedia equipment + car computer + navigation	3200	0	20.580 €	0	-6000	Silver	0	0

The buyer and the seller could only see their own point scores during the negotiation, independent of the condition. There were no restrictions made on the communication of the negotiators, including the sharing of any of this information.

The payoff schedule was accompanied by a graphical decision aid showing bar charts for each issue in the height of their highest scoring option (e. g. 4000 points for the buyer and 1600 points for the seller of the issue “financing”). These bar charts differed in their interactive capabilities and amount of information between the two conditions. Figure 1 shows a screenshot (translated from German) of the negotiation screen with graphical decision aid.

Figure 1. Negotiation Screen with Graphical Decision Aid (as seen by the seller).



5.3 Participants

One hundred thirty-two university students from different fields of study (100 female, 32 male, M_{age} = 24.01, SD_{age} = 3.70, age range: 19–36) voluntarily took part in this experimental study for an hourly rate of 8 €. We randomly assigned the roles of either the buyer or seller and thus 66 dyads were created, 33 dyads per condition with either less information and interactivity or more

information and interactivity. The distribution of gender in the dyads was controlled for by alternating the conditions for dyads consisting of female-female, male-male and female-male.

5.4 Procedure

The whole experiment took place within an experimental negotiation support system with three phases: pre-negotiation, negotiation, post-negotiation. Besides the negotiation phase, the participants worked alone. The duration was approximately one hour.

The participants were greeted and briefed shortly about the procedure of the experiment and the upcoming negotiation. After filling out a declaration of consent, they went into individual rooms and sat down in front of a computer.

5.4.1 Pre-negotiation phase. First, the participants took the figural intelligence test. After that, they answered descriptive questions about, for example, gender or age followed by questions on the perceived computer skill, effortlessness, and previous frequency of using tables/charts.

Next, the individual role and the negotiation scenario were described and the participants introduced to the graphical decision aid.

5.4.2 Negotiation phase. Further instructions were given on the negotiation interface, after which the participants put on their headsets and could begin. They had 35 minutes to find an agreement on the eight issues with five options each. They could abort the negotiation or come to an agreement at any time. The common set of marked options was logged by the experimental negotiation support system as the agreement.

5.4.3 Post-negotiation phase. The participants again worked alone after the negotiation. They were asked about details of the negotiation just concluded.

Finally, the social value orientation test was given. It was applied after the negotiation as to not influence negotiation outcomes beforehand.

In the end, the participants were paid and shortly debriefed.

5.5 Analyses

We used the actor-partner interdependence model (APIM; Kenny et al., 2006) for analyses on the individual level: to be more specific, the multilevel modelling approach (Kenny & Ledermann, 2015).

The negotiation dyads were not independent of each other and, therefore, we could not analyze the effects of different measures on the individual outcomes without taking the partner into account. The buyer and the seller have both an actor effect – the effect of one of the partner's own characteristic of a measure on his or her own individual outcome – and a partner effect – the effect of one of the partner's own characteristic of a measure on the individual outcome of the other partner. Every APIM analysis included the condition as a covariate and was repeated for each of the three different codings:

(1) Dummy coded (-1|1) to see the overall effects of a control measure on the individual outcome independent of the condition and to test for a possible interaction between the condition and the control measure.

(2) Effects coded for the non-interactive condition (0|1) to see the effects of the control measure on the individual outcome in the non-interactive condition, in case of an interaction.

(3), like (2) but effects coded for the interactive condition (1|0).

All actor-partner interdependence model analyses are based on indistinguishable dyads because the test of indistinguishability for all control measures confirmed that the individuals in the dyads were truly indistinguishable as intended by the experimental setup.

6 Results

Table 2 holds an overview of all significant results of the actor-partner interdependence model analyses. There were no condition specific results found.

Table 2

Overview of Results of the Actor-Partner Interdependence Model Analyses

Measure	Actor Effect on Individual Outcome	Partner Effect on Individual Outcome		
	β	*β*	*b*	*r*
HEXACO Emotionality	.036	**-.173**	**-337**	**-.173**
Dependence	-.039	**-.188**	**-368**	**-.184**
Sentimentality	-.087	**-.225**	**-438**	**-.221**
Anxiety	.112	-.044		
Fearfulness	.154	-.074		
HEXACO Honesty Humility	-.079	.070		
Sincerity	-.159	.101		
Fairness	-.073	-.056		
Greed Avoidance	-.041	.070		
Modesty	.039	.121		

HEXACO Extraversion	-.096	-.024		
Social Self-Esteem	-.160	.068		
Social Boldness	-.092	-.080		
Sociability	-.018	-.053		
Liveliness	-.030	-.047		
HEXACO Agreeableness	-.076	-.044		
Forgiveness	.030	.030		
Gentleness	-.082	-.088		
Flexibility	-.104	-.016		
Patience	-.113	-.068		
HEXACO Conscientiousness	.073	-.060		
Organization	-.038	-.068		
Diligence	.038	.007		
Perfectionism	.119	-.054		
Prudence	.084	-.097		
HEXACO Openness to Experience	-.085	.122		
Aesthetic Appreciation	-.051	.059		
Inquisitiveness	-.097	.121		
Creativity	-.043	.091		
Unconventionality	-.029	.076		
Social Value Orientation	.020	**.206**	**401**	**.195**
Figural Intelligence	.004	**.199**	**389**	**.191**

Besides Social Value Orientation with N = 130 individuals in N = 65 dyads (due to technical

errors) all N = 132 individuals in N = 66 dyads. Effects marked bold are significant with $p < .05$.

6.1 HEXACO

The individual characteristic of the HEXACO scale emotionality had a partner effect on the individual outcome. A negotiator's own emotionality had no influence on his or her own individual outcome but the more emotional the opposing partner was, the lower the negotiator's own individual outcome turned out to be. Two subscales of emotionality, namely, dependence and sentimentality had similar effects.

The individual characteristic of the subscale dependence also had a partner effect on the individual outcome. A negotiator's own need for emotional support from others had no influence on his or her own individual outcome but the more the opposing partner needed emotional support, the lower the negotiator's own individual outcome became.

The individual characteristic of the subscale sentimentality had a partner effect on the individual outcome too. A negotiator's own strength of feeling an emotional bond had no influence on his or her own individual outcome but the higher the strength of feeling an emotional bond of the opposing partner was, the lower the negotiator's own individual outcome turned out to be.

6.2 Social Value Orientation

The individual characteristic of the social value orientation had a partner effect on the individual outcome. A negotiator's own social orientation had no influence on his or her own individual outcome but the more social the orientation of the opposing partner was, the higher the negotiator's own individual outcome was.

6.3 Figural Intelligence

The individual characteristic of the figural intelligence had a partner effect on the individual outcome. A negotiator's own figural intelligence had no influence on his or her own individual outcome but the higher the figural intelligence of the opposing partner was, the higher the negotiator's own individual outcome was.

7 Discussion

In this experimental study, we sought to find answers on how the HEXACO personality scales and relevant measures such as figural intelligence and social value orientation affected the individual outcomes in a computer-supported negotiation. To accomplish this, we compared two conditions with negotiation support system, differing in their amount of information and interactive capabilities, which ultimately did not differ in their results. Interestingly, a negotiator's own personality traits had no influence on his or her own individual outcome. A negotiator's own individual outcome lies mostly in the hands of the opposing partner. Table 3 holds an overview of the partner's characteristics which may improve a negotiator's own individual outcome in a computer-supported negotiation.

Table 3

Partner's Characteristics that Improve a Negotiator's Own Individual Outcome Within a Negotiation Support System

Measure	Partner's characteristic
HEXACO Emotionality	Lower emotionality

Dependence	Lower need for emotional support
Sentimentality	Lower strength of feeling and emotional bond
Social Value Orientation	Higher prosocial attitude
Figural Intelligence	Higher figural intelligence

Higher emotionality, a higher need for emotional support, and a higher feeling of an emotional bond are personality traits of one negotiation partner which could elicit caring behavior in the other negotiator or a stronger emotional bond, resulting in more concessions from the other negotiator. The only other study using the direct individual outcome in connection with personality traits, as we did, showed that a higher emotionality – or neuroticism – improved the individual outcome (Foo et al., 2004). However, it seems to be true that the high emotionality of one negotiation partner does not improve his or her own individual outcome, but it instead worsens the individual outcome of the less emotional negotiation partner. Further studies are needed to fully understand the individual influence of emotionality on the individual outcomes as a higher score in this personality trait is common in the population and has a high economic cost for society (Cuijpers et al., 2010).

The higher social value orientation of one negotiation partner, improving only the individual outcome of the other, fell in line with previous research: Prosocial individuals were less demanding but simultaneously more giving and considerate (Dreu & Lange, 1995). This would explain the higher individual outcome of their negotiation partner. It is still interesting to see that social orientation of a negotiator had no influence on his or her own individual outcome.

The higher figural intelligence of the partner played an important role in the negotiation with a negotiation support system using a graphical decision aid: The understanding of the

graphical decision aid is crucial for beneficial trade-offs, and lacking the general ability to understand figural representations might hinder this process. We believe that the negotiator with a better understanding of the graphical decision aid offered more profitable concessions to the other negotiator, but in return received less profitable concessions back due to the other's lower general ability to understand the figures in form of bar charts.

One shortcoming of this experimental study is that these findings for the HEXACO scales and the findings for the Big Five are not fully comparable: (1) Although the HEXACO is very similar to the Big Five, it is not identical. (2) Previous studies did not use the actor-partner interdependence model but lesser methods to test the influence on individual outcomes. (3) Previous studies did not use the direct individual outcome measured in points but the individual deviation from a preset individual target.

More studies researching the HEXACO scales in a computer-supported negotiation, using the actor-partner-interdependence model for analysis of the direct individual outcome are needed to create a more complete knowledge base on the influence of personality traits on individual outcomes in negotiations. Also, further research is needed to fully assess the reasons, why the negotiator's own individual outcome lies mostly in the hand of the partner and stays uninfluenced by one's own characteristics.

7.1 Conclusion

Negotiators seem to compensate the deficiencies of their partner with their own share of the gain in a negotiation. Furthermore, the individual outcome of one partner seems highly dependent upon the personality and prosocial behavior of the opposing partner. The worst negotiation partner using a negotiation support system with graphical decision aids would be the one who is

emotionally unstable and competitive and who has problems interpreting figures. This negotiation partner will not feel the effects of his or her shortcomings, but the one negotiating with this partner will suffer a lower individual outcome. Asking for an experienced negotiator is therefore advisable, especially when using a computer-supported environment.

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APPENDIX C – DECLARATION OF PERSONAL CONTRIBUTION

EBERHARD KARLS
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Mathematisch-Naturwissenschaftliche Fakultät

Erklärung nach § 5 Abs. 2 Nr. 7 der Promotionsordnung der Math.-Nat. Fakultät
-Anteil an gemeinschaftlichen Veröffentlichungen-
Nur bei kumulativer Dissertation erforderlich!

Declaration according to § 5 Abs. 2 No. 7 of the PromO of the Faculty of Science
-Share in publications done in team work-

Name: Richard Kolodziej

List of Publications

1 Engelmann, T., **Kolodziej, R.**, & Hesse, F. W. (2014). Preventing Undesirable Effects of Mutual Trust and the Development of Skepticism in Virtual Groups by Applying the Knowledge and Information Awareness Approach. *International Journal of Computer-Supported Collaborative Learning*, *9*(2), 211–235. http://doi.org/10.1007/s11412-013-9187-y

2 Engelmann, T., Kozlov, M. D., **Kolodziej, R.**, & Clariana, R. B. (2014). Fostering Group Norm Development and Orientation While Creating Awareness Contents for Improving Net-Based Collaborative Problem Solving. *Computers in Human Behavior*, *37*, 298–306. http://doi.org/10.1016/j.chb.2014.04.052

3 **Kolodziej, R.**, Hesse, F. W., & Engelmann, T. (2016). Improving Negotiations with Bar Charts: The Advantages of Priority Awareness. *Computers in Human Behavior*, *60*, 351–360. http://doi.org/10.1016/j.chb.2016.02.079

4 **Kolodziej, R.**, Sassenberg, K., Thiemann, D., & Hesse, F. W. (2016). *Priority Awareness Outperforms Performance Awareness in Negotiations*. Manuscript submitted for publication.

5 **Kolodziej, R.**, & Sassenberg, K. (2016). *HEXACO Personality Traits That Shape the Individual Outcome in Computer-Supported Negotiations*. Manuscript submitted for publication.

Nr.	**Accepted for publication yes/no**	**Number of all authors**	Position of the candidate in list of authors	Scientific ideas of candidate (%)	Data generation by candidate (%)	Analysis and Interpretation by candidate (%)	Paper writing by candidate (%)
			Optional, the declaration of the own share can also be done in words, please add an extra sheet.				
1	Yes	3					
2	Yes	4					
3	Yes	3					
4	Yes	4					
5	Yes	2					

EBERHARD KARLS
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Written declaration of own share

Article 1: Most analyses, the results section, the method section, parts of the theory and discussion were created by the candidate.

Article 2: Most analyses, most of the result section, most of the method section, parts of the theory and discussion were created by the candidate.

Article 3: In large, this article was created by the candidate alone with feedback from the coauthors.

Article 4: In large, this article was created by the candidate alone with feedback from the coauthors.

Article 5: In large, this article was created by the candidate alone with feedback from the coauthors.

I certify that the above statement is correct.

_____

Date, Signature of the candidate

I/We certify that the above statement is correct.

_____

Date, Signature of the doctoral committee or at least of one of the supervisors