Instructional support for individual and collaborative demands in two net-based communication settings

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Abstract. In this paper, we present a study conducted to evaluate instructional support measures for a net-based collaborative picture-sorting task. A combination of a model collaboration presented as an on-screen video to the collaborators prior to collaboration and a collaboration script was developed to support individual cognitive as well as collaborative demands. In a 2x3 factorial design we varied the amount of support as well as the mode of communication in order to test the impact of the support on the collaboration process and performance in net-based interactive and non-interactive communication settings. The results showed an improved collaboration process in conditions with support but no significant effect on the performance measures. The support measures fostered the collaboration process even in the particularly difficult conditions with non-interactive communication.

Introduction

Two persons jointly solving a task in a net-based setting face various challenges: In addition to the individual cognitive demands inherent to a task, cognitive processes and activities have to take place due to the need to interact. The latter include collaborative task-related activities as well as meta-cognitive processes (Dillenbourg, Baker, Blaye & O'Malley, 1996). An important part of the collaborative meta-cognitive processes is related to communication: The collaborators have to establish common ground in order to achieve mutual understanding (Clark & Brennan, 1991) and solve the task together.

Furthermore, net-based communication poses additional demands on the collaborators because of the mostly restricted possibilities for communication. These additional demands differ, for example, depending on the channels available for communication (auditory, visual, text-based) and on the mode of collaboration (interactive or non-interactive) (see Rummel & Spada, 2005a). For instance, in most net-based settings, communication is impeded because the collaborators do not share the same physical environment. Thus, they cannot use visual information of the work context or non-verbal information provided by their partner's facial expression or gestures (Kraut, Fussell & Siegel, 2003). Moreover, some settings that allow only non-interactive communication impede immediate and spontaneous interactions and make effective grounding impossible.

Extensive research on collaboration has shown that successful collaboration and good results do not arise without adequate support (e.g. Slavin, 1995) and that support is particularly important for net-based collaboration (see Bromme, Hesse & Spada, 2005). The main approaches to fostering net-based collaboration have as a starting point either the 'mice' or the 'minds': The 'mice' approach aims at improving the technical environment for collaboration for example by using shared representational tools (e.g. Suthers & Weiner, 1995) or technology for remote gesturing (Kirk & Fraser, 2005). Approaches that take 'minds' as a starting point either support collaboration as it occurs through structuring interaction with collaboration scripts (O'Donnell & Dansereau, 1992; Baker & Lund, 1997) or use instructional measures to promote the skills needed for collaboration (Rummel & Spada, 2005a, 2005b).

However, in order to develop instructional measures, we need to understand in detail what skills are needed to solve a specific task. Studies of collaboration mostly use quite complex settings. As we aimed to examine the role and functioning of communication, we used a remote collaborative problem-solving task that is more restricted and enables a more detailed analysis. The task is similar to the Referential Communication Task (Krauss & Weinheimer, 1966), which has been used a great deal to study communication. However, our task holds more individual cognitive demands, as visual search processes are required to detect small differences between the pictures. In this paper, we present a study conducted to evaluate instructional support measures based upon a first, prior study that revealed the task demands (Bertholet & Spada, 2005). Further details of this previous study will be reported after the presentation of the task we used. The instructional support measures included two levels of support, one for individual cognitive demands and one for collaborative demands, and were designed to foster collaboration in interactive as well as non-interactive settings.

Research questions

We conducted the study based on the following research questions:

(1) To what extent do the instructional support measures have an impact on the interactive collaboration process and outcome?

(2) Does non-interactive collaboration also benefit from the instructional support measures?

Method

The Task Used

In our study, two persons had to jointly solve a picture-sorting task while located in two different rooms. One of the participants assumed the role of speaker and the other took the role of addressee. The task was presented on two displays, and oral communication between speaker and addressee was possible via an audio link. On the speaker's display, sixteen pictures were presented that differed only in terms of minor details. The speaker had to describe nine of the pictures and their order to the addressee (see Figure 1). The addressee saw the single sixteen pictures in a random order and had to arrange nine of them according to the speaker's description. The addressee was able to rearrange the pictures on the target area by using the mouse (drag and drop). Because the differences between the pictures were very small, the participants had to first detect these differences and then the speaker had to design appropriate utterances that enabled the addressee to choose the correct pictures by considering the relevant features. This component of feature detection constitutes the main difference from the classic Referential Communication Task, in which the task demands consist only in the verbal description of clearly different objects. This individual cognitive demand makes the task more comparable to realistic collaborative tasks in which communication often has to take place in parallel to individual cognitive processes.

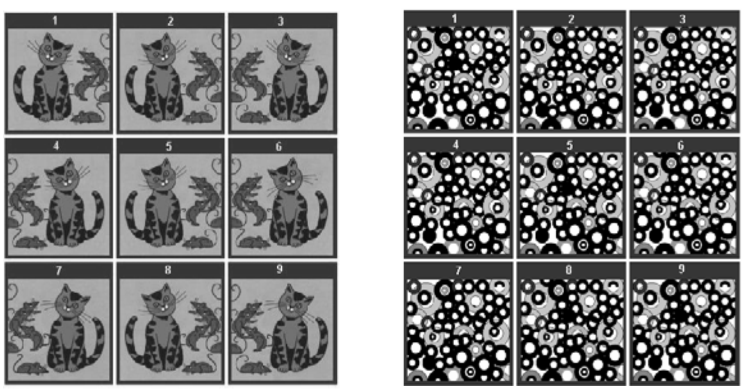

Figure 1. The nine target pictures on the speaker's display for one concrete (left) and one abstract (right) task.

Four different tasks were used, which can be categorized as 'concrete' and 'abstract' sets of pictures (see Figure 1 for examples of both types). Each dyad had to solve all four tasks. The task demands can be grouped into individual cognitive and collaborative demands (due to interaction). The first group of demands includes feature search and identification. The collaborators have to detect the relevant features that differ between the pictures (e.g. the position of the cat, the cat's line of sight, the direction of the cat's whiskers). These demands have to be dealt with individually; they would also exist if the sorting of the pictures had to be carried out by an individual instead of being part of a collaborative task. (The original children's game "Differix" by Ravensburger©, from which we took some of the pictures, consists in arranging nine pictures on a template individually, competing against one to five other players.) The second kind of demands contains the additional challenges of collaboration due to the need to communicate. The speaker has to describe the relevant feature values (e.g. "the cat's whiskers are pointing upwards") of one picture in an appropriate way and the addressee has to understand the speaker's description and to match the description to the features in the picture.

In a previous study (Bertholet & Spada, 2005), it was confirmed that the task does indeed hold individual cognitive and collaborative demands. Furthermore, the results showed different difficulties arising from the two demands for the two sets of pictures: The concrete sets hold more challenges with regard to the individual cognitive demands, and the abstract sets are more difficult in terms of the collaborative demands (due to interaction). As the concrete sets contain familiar objects, the detection of the relevant features is more error-prone because the details can be overlooked quite easily. This result is in line with findings from research on visual processing as the change blindness effect (e.g. Rensink, O'Regan & Clark, 1997). On the other hand, it is more difficult to describe the unfamiliar objects and their features in the abstract tasks because the speaker needs to invent terms and customize them for interaction. Speaker and addressee have to develop a common language in order to establish referential identity (Clark & Brennan, 1991). If they use different frames of reference, this results in specific errors in some concrete tasks. For example, the cat's line of sight can be described from the speaker's or from the cat's perspective. To enable a correct identification of the pictures, speaker and addressee must have a mutual frame of reference.

Interactive and Non-Interactive Communication

Interactive communication is the main setting for language use (Pickering & Garrod, 2004; Clark, 1996). Nevertheless, there are also settings involving non-interactive or less interactive communication such as lectures and speeches or written communication. Non-interactive settings differ from interactive ones in important points, as the speaker does not receive feedback and cannot be certain of having been understood by the addressee: Grounding (e.g. Clark & Brennan, 1991) is not possible. Furthermore, speakers tend to produce longer descriptions if they receive no feedback from their addressees (Krauss & Weinheimer, 1966), they cannot rely on terms used before (lexical alignment; Pickering & Garrod, 2004) and are therefore more careful in designing their utterances (Schober, 1993). When solving a collaborative task together, non-interactive conditions lead to an increased number of errors and it takes more time to complete the task (Clark & Krych, 2004). In spite of this, professional writers such as newspaper reporters still seem to be understood by their audience without receiving feedback, and they must have gained expertise through training and experience in terms of how to write in such a way as to be understood with minimal problems (Traxler & Gernsbacher, 1992).

Taking these results together, it is apparent that non-interactive communication is a very difficult undertaking that needs support. In order to test for possibilities for and effects of support, we included interactive as well as non-interactive conditions in our study and provided both with instructional support measures.

Instructional Support

Fostering 'minds' by using collaboration scripts can improve net-based collaboration. The prominent technique of scripted cooperation (O'Donnell & Dansereau, 1992) aims at optimizing the interaction process by sequencing it into different phases, defining roles, and assigning them to the collaborative learners. As collaboration scripts have shown themselves to be a very effective means for fostering collaboration, they have also been transferred to computer settings (e.g. Baker & Lund, 1997). Typically, they are embedded in computer-based learning environments and guide the collaborators in a step-by-step fashion through different activities. Computer-based collaboration scripts may be used not only to support learners in acquiring knowledge in a specific domain but also to support them in learning how to collaborate (Rummel & Spada, 2005a, 2005b). A second approach provides a *model collaboration* to the participants prior to the collaboration (Rummel & Spada, 2005a, 2005b). While observing such a model of a dyad collaborating, people should reflect upon the solution steps and engage in meta-cognitive activities that promote learning (e.g. Bandura, 1977; VanLehn, 1996). Both approaches have been shown to improve the collaboration, but still entail certain disadvantages: The extensive use of collaboration scripts can disturb natural interaction or cognitive processes and lead to motivational losses (overscripting; see Dillenbourg, 2002). Depending on the amount of information included, the persons watching the model collaboration might have difficulties in extracting and remembering all relevant points.

To combine the advantages of the two approaches, we developed instructional support measures integrating both. Based on the results of a previous study (Bertholet & Spada, 2005) and following the approach of Rummel and Spada (2005b), we developed a model collaboration for the collaborative picture-sorting task. It was presented to the dyads as an on-screen video with audio instructions prior to the collaboration. In addition, a collaboration script reminding the collaborators of what they had just learned before was provided during the collaboration. This combination should promote effective collaboration, as we expect the model collaboration video to have positive effects on the participants' attention and motivation (Bandura, 1977) and the collaboration script to enhance the memory for the relevant information. Both the model instruction and the script contained two levels of support, each corresponding to one of the two demands: level 1 supporting the individual cognitive demands and level 2 supporting the collaborative demands. The instructions mainly concerned the meta-processes to promote effective coping with the two demands. Table 1 shows examples for task-related activities and meta-processes related to the two demands.

Table 1. Task-related activities and meta-processes for individual cognitive and collaborative demands.

	Demands	
	Individual cognitive	*Collaborative (interaction)*
Task-related activities	e.g. Visual search for feature differences	e.g. Description of the pictures
Meta-processes	e.g. Checking whether all necessary features were found	e.g. Establishment of mutual understanding of features' names, frame of reference etc.

Each support level contained hints for dealing with the respective demand (e.g. "In concrete pictures, differences are often overlooked. Please check carefully if you have found all relevant differences.") and, moreover, each level introduced one subtask: Marking the features in an individual picture editor (level 1) and writing the features' names into an individual text editor (level 2). A screenshot of a speaker's on-screen video is presented in Figure 2. It shows the individual picture and text editor on the right.

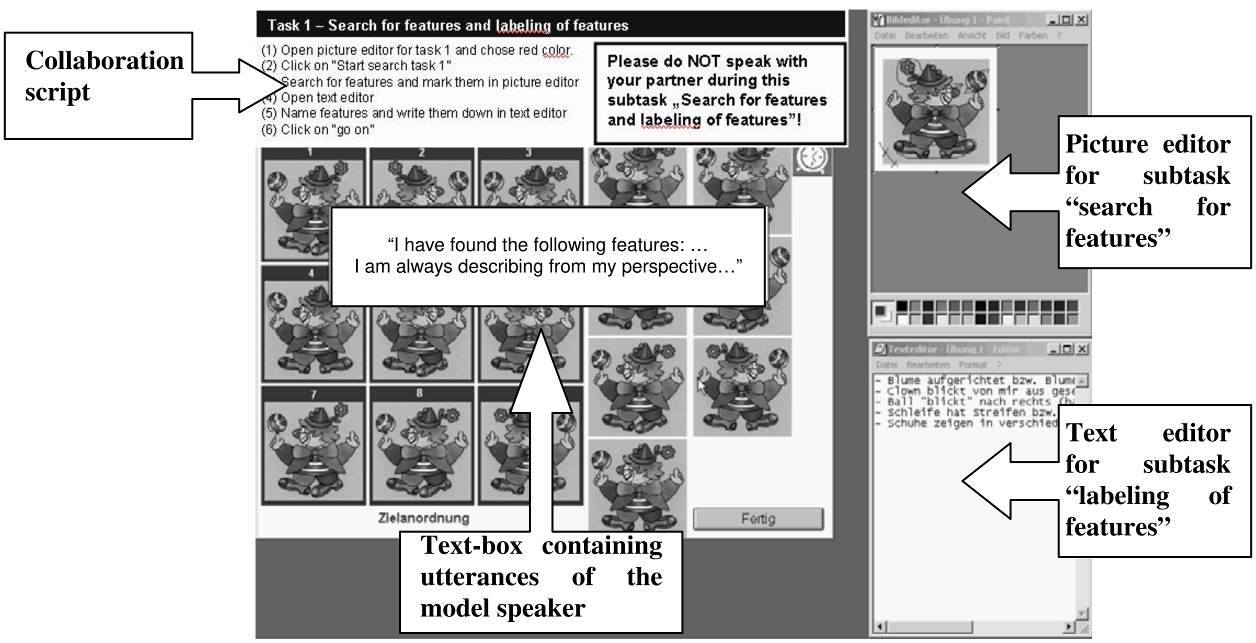

Figure 2. Screenshot of a speaker's on-screen video (condition 'support level 1+2/ interactive mode of communication')

Experiment

Design

A 2x3 factor design was used (see Table 2) with the type of picture (concrete/ abstract) as an additional within-subject factor. Each dyad was required to solve all four tasks but in different sequences: To control for sequence effects, four different task sequences were given. As one between-subject factor, the amount of support was varied (complete support – level 1+2 vs. only support of individual demands – level 1 vs. no support). As a second between-subject factor, the mode of communication was varied, being either interactive or non-interactive. Each participant was assigned randomly to one of the six conditions.

Table 2. Design of the study.

		Mode of communication	
		Interactive	*Non-interactive*
Amount of support	Level 1 + 2 (complete support)	concrete/ abstract	concrete/ abstract
	Level 1 (only indiv. demands)	concrete/ abstract	concrete/ abstract
	No support	concrete/ abstract	concrete/ abstract

Participants

Ninety-six students (48 dyads) from the University of Freiburg, Germany participated in the study. Thirty-six of the participants were male and 60 female. The participants had an average age of 24.15 years (*SD* = 4.4, range = 18 to 48). All participants were German native-speakers. Each participant received 15 Euros for his/ her participation. The participants were randomly grouped into dyads and assigned the role of speaker and addressee. Participants did not know each other prior to the study.

Procedure

Prior collaboration, the participants individually received instructions including technical advices in the form of an on-screen video. Depending on the condition, the video included only technical advices (no support conditions) or further contained the support of the cognitive (level 1 support) or of both demands (level 1 and 2 support). In both support conditions, the participants observed either a model speaker or a model addressee successfully solving a task. Level 1 support contained hints for feature search and introduced the first individual subtask (marking the differences in the individual picture editor). Moreover, level 1 and 2 support included hints for dealing with the collaborative demands and additionally introduced the second individual subtask (writing feature's names in the individual text editor). After watching the on-screen video, the dyads performed a training task (including the description and positioning of three pictures out of sixteen) in order to familiarize themselves with the technical environment and the subtasks. During the experimental phase, each dyad was required to solve four tasks.

In the non-interactive conditions, the speaker and addressee performed the tasks not at the same time, but rather one after another. The speaker had a recording device on the display and could start and stop recording the explanations to the addressee as he/ she desired. A microphone was positioned on the table next to the monitor. The description of each speaker was randomly assigned to one addressee, who later arranged the pictures according to the recorded descriptions. The addressee had an audio-player device on the display and could start, stop and rewind the recording of the speaker's descriptions as often as he/ she desired. However, speakers and addressees in both the non-interactive and interactive conditions were told to proceed as accurately and quickly as possible.

Measures

Two sets of data were collected to examine the collaboration process as well as the outcome: Audio recordings of the communication and performance measures.

The coding scheme for the communication data emphasizes different kinds of problems and errors made during collaboration (Table 3). The categories refer to the two demands on the collaborators: The first two categories to the individual cognitive demands, and categories 3 to 7 to the collaborative demands (due to interaction). The audio recordings of the communication were analyzed using these problem and error categories as well as some additional categories. To check for inter-rater reliability, ten percent of the verbal data was coded by a second rater. The consistency of the coding was medium to high, with $ICC_{\text{just,fixed}}$ (intra-class correlation; see Shrout & Fleiss, 1979) between .66 and 1.0, indicating that the coding scheme could easily be used.

Table 3. Coding scheme for the problems and errors occurring during communication.

Individual cognitive demands	
• *Number of not identified features*	How many relevant features were NOT identified?
• *Number of errors 'Feature not mentioned'*	How often did the speaker give descriptions in which relevant features were not mentioned?
Collaborative demands (due to interaction)	
• *Number of features not mentioned before description*	How many relevant features were NOT mentioned by the speaker before starting the description of the first picture?
• *Number of errors 'Name of feature'*	How often did the speaker give descriptions that were ambiguous regarding the feature's name?
• *Number of errors 'Frame of reference'*	How often did the speaker give descriptions that were ambiguous regarding the frame of reference?
• *Number of irrelevant features*	How often did the speaker give descriptions of irrelevant features?
• *Number of complicated descriptions*	How often did the speaker give complicated and pedestrian descriptions of a feature?

The performance measures included: The number of pictures placed in the correct position at the end of one task and the time needed for description and positioning of the pictures.

Results and discussion

We computed a MANOVA with repeated measures (for the factor 'type of pictures') to test the influence of the three factors on process and performance measures. Due to the limited space of this paper, we do not report all of the dependant variables included in the MANOVA, but only the categories described in Table 3. As an ANOVA revealed no effect of the task order, this factor will not be taken into account in the following analyses.

There was an effect of the type of pictures ($F[11, 32] = 16.4$, $p < .01$, $\eta^2 = .85$), an effect of the amount of support ($F[22, 66] = 2.8$, $p < .01$, $\eta^2 = .48$) and an effect of the mode of communication ($F[11, 32] = 9.6$, $p < .01$, $\eta^2 = .77$). Additionally, there was a significant interaction between the type of pictures and the mode of communication ($F[11, 32] = 2.7$, $p > .01$, $\eta^2 = .48$). ANOVAs were calculated for all variables. The results will be reported separately for the process data and the performance measures.

Process Data: Audio Recordings

Table 4 contains means and standard deviations for the process variables included in the MANOVA, with each column corresponding to one factor. Overall, the standard deviations are quite high for most of the variables, showing that there were quite large differences between the dyads. For the type of pictures, there were significant differences in all seven problem and error categories. The results showed that more problems and errors related to the individual cognitive demands occurred in concrete tasks with a higher *number of not identified features* ($F[1, 42] = 49$, $p < .01$, $\eta^2 = .54$) and a higher *number of errors 'feature not mentioned'* ($F[1, 42] = 80.6$, $p < .01$, $\eta^2 = .66$). There was also a higher *number of errors 'frame of reference'* ($F[1, 42] = 14.7$, $p < .01$, $\eta^2 = .26$), because of the need to find a mutual frame of reference in concrete tasks. However, the *number of features not mentioned before description* ($F[1, 42] = 80.5$, $p < .01$, $\eta^2 = .66$), as well as a the *number of irrelevant features* ($F[1, 42] = 28.4$, $p < .05$, $\eta^2 = .40$), both of which are problems related to the collaborative demands, also occurred more often in concrete tasks. This may be due to an illusion of simplicity (Nickerson, 1999) arising for the concrete sets of pictures: When beginning to solve a concrete task, dyads underestimated the difficulties, did not find all relevant features and failed to install a mutual frame of reference. Later on in the collaboration, when the problems became obvious, a high number of irrelevant features were described because the relevant ones had still not been identified. As expected, two problems or errors related to the collaborative demands, t*he number of errors 'name of feature'* ($F[1, 42] = 22.2$, $p < .01$, $\eta^2 = .35$) as well as *the number of complicated descriptions* ($F[1, 42] = 21.8$, $p < .01$, $\eta^2 =$

.34) arose more often in abstract tasks. As can be seen in Table 4, the means of problems and errors during communication differed mostly in the expected way between the conditions with complete support, only support of individual demands and without support: In general, fewer problems and errors occurred in conditions with support. Nevertheless, there were significant differences only in *the number of errors 'feature not mentioned'* ($F[2, 42] = 5.2$, $p < .05$, $\eta^2 = .20$) and in *the number of features not mentioned before description* ($F[2, 42] = 14.1$, $p < .01$, $\eta^2 = .40$). As expected, both errors were mostly made by dyads in conditions without support. For the mode of communication, the means of problems and errors during communication also differed mostly in the expected way: Fewer problems and errors occurred in interactive conditions. However, there were only significant differences in *the number of not identified features* ($F[1, 42] = 52.1$, $p < .01$, $\eta^2 = .55$), in *the number of errors 'feature not mentioned'* ($F[1, 42] = 17.9$, $p < .01$, $\eta^2 = .30$), and in *the number of features not mentioned before description* ($F[1, 42] = 8.4$, $p < .01$, $\eta^2 = .17$). As expected, all three errors were made more often in dyads with the non-interactive mode of communication.

Table 4. Means and standard deviations (in parentheses) of the process data.

Dependent variable	*Type of pictures*	*Amount of support*	*Mode of communication*
Number of not identified features	concr.: 2.1 (1.8) abstr.: 0.7 (1.3) **	lev.1+2: 1.4 (1.3) lev.1: 1.2 (1.3) no train.: 1.8 (1.9) *ns*	inter.: 0.5 (0.7) non-inter.: 2.4 (1.5)**
Number of errors 'Feature not mentioned'	concr.: 27.1 (14.3) abstr.: 9.2 (12.6)**	lev.1+2: 14.4 (11.5) lev.1: 15.9 (10.3) no train.: 24.5 (14.6)*	inter.: 12.6 (10.5) non-inter.: 23.7 (13.7)**
Number of features not mentioned before description	concr.: 6.9 (3.2) abstr.: 4.4 (3.7)**	lev.1+2: 3 (2.7) lev.1: 6.2 (1.3) no train.: 7.7 (2.8)**	inter.: 4.6 (3.5) non-inter.: 6.7 (3.1)**
Number of errors 'Name of feature'	concr.: 0 (0) abstr.: 1.2 (1.8)**	lev.1+2: 0.5 (0.8) lev.1: 0.7 (1.2) no train.: 0.7 (0.8) *ns*	inter.: 0.4 (0.7) non-inter.: 0.8 (1.0) *ns*
Number of errors 'Frame of reference'	concr.: 2.7 (4.8) abstr.: 0 (0)**	lev.1+2: 0.5 (0.8) lev.1: 1.4 (3.2) no train.: 2.1 (2.4) *ns*	inter.: 1.4 (2.3) non-inter.: 1.3 (2.2) *ns*
Number of irrelevant features	concr.: 13.7 (13) abstr.: 3.1 (7) **	lev.1+2: 6.9 (9.4) lev.1: 8.3 (9.4) no train.: 9.9 (6.1) *ns*	inter.: 8 (9.9) non-inter.: 8.7 (10.2) *ns*
Number of complicated descriptions	concr.: 0.4 (1.4) abstr.: 2 (3.2) **	lev.1+2: 0.6 (1.3) lev.1: 1.2 (1.6) no train.: 1.8 (2.5) *ns*	inter.: 0.8 (1.8) non-inter.: 1.6 (2.8) *ns*

** p <.01; * p < .05; *ns* no significant effect

There were significant interactions between the type of pictures and the mode of communication for *the number of not identified features* ($F[1, 42] = 8.3$, $p < .01$, $\eta^2 = .17$), *the number of features not mentioned before description* ($F[1, 42] = 8.1$, $p < .01$, $\eta^2 = .16$), and *the number of complicated descriptions* ($F[1, 42] = 4.5$, $p < .05$, $\eta^2 = .10$). In concrete tasks, the number of problems and errors related to the individual demands and in abstract tasks those related to the collaborative demands were higher for non-interactive conditions.

To summarize: The analysis of the audio recordings revealed, as expected, more problems and errors related to the individual cognitive demands as well as more errors 'frame of reference' in concrete sets of pictures. In abstract sets of pictures, there were more problems and errors related to collaborative demands. The developed instructional support measures had a positive effect on the collaboration process, with fewer problems and errors occurring in conditions with support. Indeed, non-interactive communication was more difficult, with more problems and errors occurring in non-interactive conditions.

Performance Measures

Table 5 shows means and standard deviations for the performance measures. The means of correctly placed pictures have to be related to a maximum number of 18 correctly placed pictures. For concrete and abstract types of pictures, the maximum number of correctly placed pictures is 18 respectively (2 tasks x 9 pictures). To keep the mean values comparable, the means of the other two factors were divided by 2. Again, each column corresponds to one factor.

Table 5. Means and standard deviations (in parentheses) of the performance measures.

Dependent variable	*Type of pictures*	*Amount of support*	*Mode of communication*
Number of pictures placed in correct position (max. 18)	concr.: 5.9 (7.5) abstr.: 13 (7.2)**	lev.1+2: 9.3 (7.2) lev.1: 10.3 (6.5) no train.: 8.9 (8.5) *ns*	inter.: 14.4 (3.9) non-inter.: 4.6 (5.2)**
Time needed for description and positioning of the pictures (in sec.)	concr.: 1063.5 (499.4) abstr.: 1057.6 (471.7) *ns*	lev.1+2: 896.2 (371.2) lev.1: 1103.2 (509.2) no train.: 1182.3 (538.4)*	inter.: 1135.5 (483.1) non-inter.: 985.7 (438.4) *ns*

** $p < .01$; * $p < .05$; *ns* no significant effect

More abstract pictures were *placed in the correct position* than concrete pictures ($F[1, 42] = 39.1$, $p < .01$, $\eta^2 = .48$). However, there was no significant difference in the *time needed for description and positioning of the pictures*. This also points toward an illusion of simplicity (Nickerson, 1999) occurring for concrete tasks. Dyads without support took more *time for description and positioning of the pictures* than dyads with support of the individual demands as well as dyads with the complete support. Dyads with the complete support were faster than dyads of the other conditions ($F[2, 42] = 2.5$, $p < .05$, $\eta^2 = .11$). There was no significant difference in the *number of correctly placed pictures* between the conditions with different amounts of support. Dyads with the interactive mode of communication placed more *pictures in the correct position* than dyads with the non-interactive mode of communication ($F[1, 42] = 72.6$, $p < .01$, $\eta^2 = .64$). However, there was no significant difference in the *time needed for description and positioning of the pictures* between the interactive and non-interactive conditions. This is due to the significant interaction between the type of pictures and the mode of communication that occurred for the *time needed for description and positioning of the pictures* ($F[1, 42] = 17.4$, $p < .01$, $\eta^2 = .29$). In the interactive conditions, dyads took more time for concrete tasks. If necessary, dyads in the interactive conditions could search for the feature differences together or take additional time for establishing a mutual frame of reference. In the non-interactive conditions, the dyads took more time for abstract tasks; speakers took more time to describe unfamiliar objects if they did not receive any feedback from their addressee.

Discussion and Outlook

The aim of the study was to evaluate instructional support measures designed to support individual cognitive as well as collaborative demands (due to interaction) in a net-based picture-sorting task. The support should foster collaboration in interactive as well as in non-interactive communication settings. The *instructional support measures* included specific help for both kinds of demands realized in two levels. To evaluate the impact of these two levels on the collaboration process and outcome, the amount of support was varied. As it is impossible to give hints for the labeling of the features without emphasizing the need to carefully search for features, the two levels could not be realized independently. To investigate the impact of the two levels, the conditions with level 1 support were only compared with the conditions that received the complete support (level 1 + 2). The analysis of the verbal data indeed showed differences in the problems and errors depending on the amount of support: In line with expectations, the problems and errors related to the individual cognitive demands were higher for the conditions without support and relatively similar in the two support conditions that both received hints for feature search and a subtask with an individual picture editor. The numbers of problems and errors related to the communicative demands were also highest for the conditions without support, but these were relatively close to the numbers of errors in the level 1 support conditions. The differences across the support conditions were significant only for the number of errors ‘feature not mentioned’ and the number of features not mentioned before description, but for the other problems and errors the means showed the expected tendencies, namely fewer problems and errors in conditions with support. So far, the instructional support measures seem to have improved the collaboration process in the intended way. Unfortunately, the impact of the measures did not reflect on the performance measures unanimously: The complete support conditions did indeed take less time for the description and positioning of the pictures, but there were no significant differences between the numbers of correctly placed pictures for the three support conditions.

A further goal of the study was to illuminate the processes in *non-interactive collaboration* and to test whether the process and performance of non-interactive dyads could also be enhanced by the designed instructional measures. As reported by different authors (e.g. Clark & Krych, 2004), the non-interactive conditions had more difficulties in solving the tasks in an appropriate way. As expected, the numbers of all seven problems and errors were higher in non-interactive conditions (significant differences only for the number of not identified features, the number of errors 'feature not mentioned', and the number of features not mentioned before description). The illusion of simplicity seems to have been higher in non-interactive conditions, since the number of features that the speaker did not identify at all was particularly high for concrete tasks. In non-interactive conditions, the 'need for security' was also higher in abstract tasks, which again gives rise to the supposition of an illusion of simplicity. One main difficulty of abstract tasks is to find appropriate expressions to describe the features. This was especially pronounced in non-interactive conditions, where a high number of complicated descriptions occurred in abstract tasks. The number of pictures not mentioned before starting the description was equally high in both types of tasks, in contrast to interactive conditions, where it was quite low for abstract tasks. The advantage of interactive communication was also evident from the performance measures: The interactive conditions outperformed the non-interactive conditions with a higher number of correctly placed pictures. There was no significant difference in the time needed for description and positioning of the pictures, but as expected, the mean time was slightly longer in interactive conditions. An interesting interaction effect occurred for this second performance measure: Non-interactive dyads took more time to complete abstract tasks, while interactive dyads took more time to complete concrete tasks. This result points in the same direction as the interaction effects for the errors and problems coded from the collaboration process. The illusion of simplicity seems to be more prevalent in non-interactive conditions and at the same time the speaker has more difficulties in finding short and comprehensible expressions for the features in abstract tasks. In line with the assumptions of Clark and colleagues (e.g. Clark, 1996), unidirectional communication or the production and reception of monologues in non-interactive communication is not as efficient as the interactive and bidirectional communication process. The higher amount of time needed for concrete tasks in interactive conditions is presumably due to problems in establishing a mutual frame of reference (Bertholet & Spada, 2005).

To summarize: The dyads without support faced various problems: Speaker and addressee were confused about how to deal with the different demands at the same time, and therefore made many errors. By contrast, the dyads with support seemed to have learned how to collaborate: The collaboration process contained fewer problems or communication errors. For future research, it would be interesting to identify the reason why the improved collaboration process had no impact on the dyads' performance. We took a first step in this direction by relating the number of correctly placed pictures with the time needed for description and positioning of the pictures. We did not include this analysis due to the limited space of this paper. In the support conditions, less time was needed to place a greater number of pictures in a correct position than in conditions without support. It can be assumed that the support might have shown effects on the performance measures in the future; i.e. if more pictures had to be described and positioned. However, further research is needed in order to gain better insights into the possible long-term effects of the instructional support measures. Fostering 'minds' with a combination of an on-screen video containing a model collaboration and a collaboration script to help structure the collaboration process therefore seems, so far, to be a promising approach to fostering collaboration for interactive and also for the particularly difficult non-interactive communication setting. Furthermore, the results suggest the need for both support levels. Particularly for concrete tasks, the support of both demands is crucial and should contain instructions to assure a mutual frame of reference.

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