Map-Mediated Dialogues: Effects of Map Orientation Differences and Shared Reference Points on Map Location-Finding Speed and Accuracy

Rick van der Kleij and **Guido te Brake**, TNO Defence, Security and Safety, Soesterberg, Utrecht, Netherlands

Objective: The effects of individual differences in map orientation on a location-finding dyadic team task were examined in a controlled experimental setting.

Background: Research on maps has been mainly directed at individuals navigating with cartographic maps. An important question remains about how to present information about others' locations to distributed team members.

Method: In a repeated-measures factorial design, distributed dyad members had to reach a shared understanding through map-mediated human-to-human dialogues about specific preset locations on digitized maps. Maps were rotated independently to different degrees, which produced alignment differences of various magnitudes between both members. Some of these maps were complemented with additional geospatial information (i.e., landmarks, compass rose, and map grid) to provide for shared reference points.

Results: Dyads using maps with identical orientations for both members performed the task more accurately than dyads using maps that varied in orientation between dyad members. The addition of geospatial information to maps providing for shared reference points helped the teamwork. Distributed dyads using maps that vary in orientation between dyad members benefit more from shared reference points than dyads using maps with orientations that are identical for both members.

Conclusion: We conclude that shared reference points help distributed dyads using maps that vary in orientation between dyad members to perform as well as dyads using maps with identical alignment.

Application: This article shows how to provide support for team coordination in distributed settings and facilitates the development of groupware to support distributed teamwork.

Keywords: groupware, communication, distributed teamwork, location finding, map alignment differences

Address correspondence to Dr. Rick van der Kleij, TNO Defence, Security and Safety, Business Unit Human Factors, Kampweg 5, P.O. Box 23, 3769 ZG Soesterberg, Netherlands; rick.vanderkleij@tno.nl.

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INTRODUCTION

The knowledge of others' locations, or mutual location awareness, appears to be pertinent for social interactions (Johansson, Trnka, & Granlund, 2007; Nova, 2007; van der Kleij, de Jong, te Brake, & de Greef, 2009). An important question is how to present information about others' locations to mobile virtual teams. We define mobile virtual teams as geographical distributed teams of which the members are not fixed to a specific location. A typical example is a team of fielded first responders working together from different locations during a crisis response operation.

Communication about locations and routes is a basic and frequent task among fielded first responders while conducting higher level tasks, such as coordination and planning. Hence, it is important to represent geospatial information as clearly as possible to limit error and prevent communication mishaps. Cartographic maps are a quintessential example of representing geographic information about others' locations. Maps can be used to present this information and are ideal for sharing location-based information, for example, about the location of an incident or ambulances.

Research on maps has been mainly directed at individuals navigating with cartographic maps, for example, in hypermedia environments or while using navigation equipment (for an overview, see Montello, 2005). Research that has focused on collaboration with the use of maps is more scarce (Convertino, Ganoe, Schafer, Yost, & Carroll, 2005; Hund, Haney, & Seanor, 2008; MacEachren, Cai, Sharma, Brewer, & Rauschert, 2005; van der Kleij et al., 2009). Moreover, according to the National Academy of Sciences, there appears to be a serious shortage of geospatial technologies that provide direct support for team efforts (Muntz et al., 2003). This article describes a controlled laboratory experiment that investigates how map orientation differences between dyad members in a distributed setting affect map location-finding speed and accuracy. Moreover, this article gives directions on how to support team coordination in mobile virtual teams, the organization of distributed teamwork, and map-mediated humanto-human dialogues.

Map Alignment and Teamwork

An important design issue for groupware representing geographic information, for example, about others' locations, is the choice between heading-up maps and navigation maps that are aligned in a fixed orientation, such as north-up maps. North-up maps are presented with north always shown on top. Hence, north-up maps depict the world always in the same way. Heading-up maps (sometimes called head-up, forward-up, track-up, or rotating maps) adapt to the movement and orientation of the user. rotating the map such that the heading of the user is at the top of the map (i.e., the top of the map is congruent with the forward view of the user). The advantage of a head-up alignment is that the locations of the map's symbols are congruent with their actual positions in the forward view (Aretz & Wickens, 1992). With a north-up alignment, there is an incongruity between the information presented on the map and the perceptual information obtained from the forward view.

Heading-up maps are typically favored, especially for individual navigational tasks or while performing a targeted search (Darken & Cevik, 1999; Viita & Werner, 2006; Wickens, Liang, Prevet, & Olmos, 1996). Targets are generally found more quickly, and at the same time, less cognitive effort is required (Viita & Werner, 2006). Viita and Werner (2006) argue that using heading-up maps lowers the need to mentally rotate the map to align it to one's position.

Notwithstanding the indisputable benefits of heading-up maps for individual navigational tasks, a heading-up alignment may seriously interfere with teamwork. Navigation maps that are aligned in a fixed orientation provide context from which deictic reference (e.g., left, up, north, and south) is made. In other words, the orientation of a map must be understood first to interpret the meaning of words and phrases that depend on contextual information (e.g., this, that, and there). It is well imaginable that members of fielded virtual teams use different maps or map orientations and, consequently, have more difficulties to refer quickly and easily to people, locations, and objects on maps. Hence, it becomes more difficult to coordinate the teamwork and to exchange contextual information.

The present research was set up to investigate the effects of differences in map orientation between distributed dyad members on teamwork. Moreover, we investigate whether maps that are complemented with additional geospatial information to provide for shared reference points will help distributed dyads to improve their teamwork. The following hypotheses are put forward:

- *Hypothesis 1:* Distributed dyads using maps with orientations that are identical for both members will find locations on a map faster and more accurately and will exchange location-based information more efficiently than dyads using maps that vary in orientation between both members.
- *Hypothesis 2:* Distributed dyads that have the use of shared reference points on maps, such as land-marks, will find locations on a map faster and more accurately and will exchange location-based information more efficiently than dyads without the use of reference points.
- *Hypothesis 3:* Distributed dyads using maps that vary in orientation between team members will benefit more from shared reference points on maps than dyads using maps with orientations that are identical for both members.

METHOD

Participants

For the present study, 28 females, primarily university students, took part. Given the now large literature documenting gender differences in navigation strategies (e.g., Dabbs, Chang, Strong, & Milun, 1998; Galea & Kimura, 1993; Sandstrom, Kaufman, & Huettel, 1998), we choose to exclude males from participating to increase power by reducing within-group variability (Stevens, 2002). Participants were randomly allocated to 14 dyads. Their age ranged from 18 to 27 years (M=22.21, SD=2.20). Participants were paid \in 45, or approximately US\$65, for their contribution in the experiment. Furthermore, the best-performing dyad was held out the prospect of an extra bonus of \in 60 to enhance motivation, create goal interdependency, and stimulate dyads to perform at their best. None of the dyad members knew each other prior to the experiment.

Task and Apparatus

Dyad members were seated at a table behind a 20.1-in. NEC multisync LCD 2080UX+ computer screen $(1,600 \times 1,200 \text{ pixels}; 60 \text{ Hz};$ 32 bit) and a Dell Precision T3400 dual-core Pentium computer equipped with Microsoft Windows XP SP 2 and a NVIDIA Quadro FX1700 512 MB graphical adapter. A twocomputer network was created using a crossover Ethernet cable. The experimental setup is depicted in Figure 1.

On the computer screens of both participants, a digitized map of a part of a fictitious city appeared with an outline of 26×26 cm (1,024 × 1,024 pixels, 24 bits per pixel color). The computer screens were at approximately 60 cm from the participants' eyes and perpendicular in the line of sight. The participants were seated in front of each other in the same room but were separated by a large partition screen to prevent them from using deictic gestures (i.e., pointing). The task required distributed dyadic team members to reach a shared understanding through a map-mediated human-to-human dialogue about a specific preset location on digitized maps (see also Figure 2).

For each dyad, a crosshair of approximately 1.5 cm in diameter appeared on the screen of one of the participants. The location on the map was generated randomly by the computer. The participant's task was to start a dialogue and give the precise location of the center of the crosshair to the other participant. This other participant then had to pinpoint the correct location on her map as swiftly and accurately as possible and click on it with the mouse. Then, an image of the correct and the chosen location was shown to both participants, and after a few seconds, a new map was shown to the participants.

Each participant had 16 turns in an experimental block. The order of turns was chosen



Figure 1. Picture showing the experimental setup (staged).

randomly by the computer but with the restriction that participants had an even amount of turns in each experimental block.

Procedure

After arrival, each participant was led to a separate work space, each of which contained a monitor and a pointing device. When participants were seated, written and oral instructions about the task were given. Then, participants were given informed consent forms and a short preexperimental questionnaire about demographic characteristics and experience with teamwork, navigation tools, and so forth.

The experiment consisted of seven blocks. The first two blocks were training blocks, which we told participants before they started working. Training blocks varied in whether both participants always had data presented with the same orientation or in different orientations. The training blocks were set up to familiarize participants with the task, the experimental conditions, and communicating with each other. Each training block contained 16 trials and lasted 10 min. After each training block, the experimenter allowed dyads to discuss their performance and work strategies. Then, the experimental blocks began. Each experimental block lasted for approximately 20 min and contained 32 trials. A Latin square design was applied to ensure that the heading-up and northup blocks were equally divided across dyads and order of appearance.

After each experimental block, the participants individually filled in a questionnaire that





measured information exchange. Furthermore, a semistructured interview was conducted to subjectively evaluate the four basic versions of the map and combinations of these map versions. Then, the participants were debriefed and interviewed together about the experiment, thanked for their cooperation, and excused.

Design and Independent Variables

We tested our hypotheses in a repeatedmeasures factorial design, meaning that each dyad received all treatments. Map orientation was presented in five separate blocks for which the order of presentation was counterbalanced across dyads. Map orientation refers to the relationship between directions on a map and compass directions.

In four nonidentical-orientation blocks, maps were rotated independently to different degrees, producing alignment differences of various magnitudes between both members. In the nonidentical-orientation blocks, the map rotation for each of the eight maps varied across trials between 0° , 90° , 180° , and 270° (-90°), resulting in 32 trials. In these blocks, the map orientations between the participants were also varied between 0° , 90° , 180° , and 270° . Participants were told at the start of the block that the map orientation was randomly varied across trials for both participants.

In the identical-orientation block, the map orientation for each of the eight maps also varied across trials between 0°, 90°, 180°, and 270°. However, in this block, the map orientations in each trial were identical for both participants, resulting in 8 trials, which were repeated four times. Before the start of this block, the participants were also told that map orientations varied randomly across trials but that both dyad members would always have the same map orientation. This block served as a control for determining the effect of using identical-orientation maps in dyads. Dyads received two training blocks, one nonidentical-orientation block and one identical-orientation block, of 16 trials each and five experimental blocks of 32 trials each.

Because we were interested in the effects of reference points on team performance, a rectangular grid-based spatial index, a compass rose, and abstract landmarks were added to the map (see Figure 2). The compass rose was always depicted in the upper right corner of the map, irrespective of the current map rotation. For the experiment, we designed eight unique abstract landmarks in two distinct colors that would be recognizable in each rotation of the map. We were especially interested in the effects on teamwork of including additional navigational information to talk about on the map. We expected that this would make pinpointing a location on a map easier, irrespective of map rotation.

In total, there were eight map versions in circulation: the basic map, the basic map with a grid, the basic map with a compass rose, the basic map with extra landmarks, and combinations of grid, compass rose, and landmarks on the basic map. The map versions were presented in random order to the dyads; each dyad received each map version four times per experimental block. Thus, each dyad received a total of 160 trials. Because order had no effects whatsoever, it is not discussed further.

Dependent Variables

We chose to collect both objective performance data and subjective data. Collecting subjective data has the benefit that it may provide significant insights not obtainable by objective methods, such as user opinions and preferences (cf. Cushman & Rosenberg, 1991). We discuss these measures in more detail.

Objective performance data. To objectively assess the dyad's performance, two task-related measures were taken: accuracy and task duration. Accuracy was defined as the distance between the actual location of the crosshair on the computer screen of one of the participants and the location chosen by the other participant. The smaller the difference was, the higher the accuracy. Task duration was the time in milliseconds it took the participants to complete the trial.

Participant ratings. Interdependent dyads need to act in concert, and smooth and efficient information exchange is essential to their task. To evaluate the perceived completeness, speed, and amount of location-based information exchange during task performance, a rating scale was administered at the end of each

Dependent variable	Geospatial Information	Map Orientation	
		Identical	Nonidentical
Accuracyª	None (base map)	38.81 (30.31)	57.30 (33.37)
	Landmarks	24.23 (18.94)	44.88 (24.84)
	Compass rose	46.22 (61.37)	39.16 (22.06)
	Map grid	16.78 (10.00)	17.65 (3.51)
	Map grid + landmarks	13.46 (5.76)	16.85 (6.32)
	Map grid + compass rose	12.98 (5.93)	14.80 (4.51)
	Landmarks + compass rose	61.04 (72.58)	30.27 (13.20)
	Map grid + landmarks + compass rose	20.50 (19.76)	16.69 (4.91)
Task duration ^ь	None (base map)	39.08 (18.56)	44.25 (8.58)
	Landmarks	26.55 (11.09)	32.07 (7.05)
	Compass rose	38.61 (19.06)	37.01 (8.75)
	Map grid	20.02 (9.74)	22.29 (6.64)
	Map grid + landmarks	21.08 (8.03)	21.90 (6.74)
	Map grid + compass rose	20.11 (6.25)	20.01 (5.80)
	Landmarks + compass rose	27.63 (8.10)	32.13 (7.30)
	Map grid + landmarks + compass rose	19.98 (7.61)	21.32 (5.63)
Information exchange ^c		5.60 (0.58)	5.41 (0.60)

TABLE 1: Summary of Cell Means and Standard Deviations as Function of Geospatial Information and Map Orientation (N = 14)

Note. Values enclosed in parentheses represent standard deviations.

^aThe values represent mean performance scores in millimeters. Hence, the lower the score, the better the performance.

^bThe values represent the average time in seconds for the team to complete each trial.

^cThe values represent mean scores on 7-point Likert-type scales.

experimental block. The information exchange rating scale was adapted from van der Kleij, Rasker, Lijkwan, and De Dreu (2006) and contained three items (Cronbach's $\alpha = .76$). Furthermore, a structured interview was conducted with both participants at the end of the experiment to subjectively evaluate the eight map versions used throughout the experiment. With regard to overall subjective evaluation, participants were asked to specify which type of map they liked best and which they liked least.

RESULTS

In all tests, an alpha level of .05 was used to determine statistical significance. The analyses were performed at the dyad level to account for statistical interdependence (Kenny, Kashy, & Bolger, 1998). The structured interview to evaluate the four basic versions of the map and combinations of these map versions was administered and analyzed at the individual level. All multiple-comparison posttests were performed without correction for multiple comparisons with the use of Fisher's LSD test. Table 1 summarizes the means and standard deviations for the dependent variables across conditions.

Dyad Performance: Accuracy

Identical versus nonidentical map orientation. For the base map, an independent t test was used to determine whether there was a difference in accuracy between map orientation conditions when no alignment differences were present between both participants (i.e., all conditions involving a 0° difference in map rotation between participants). This revealed a significant difference, t(13) = -1.89, p = .04 (one sided), with identical-map-orientation conditions leading to significantly higher accuracy than nonidentical-map-orientation conditions.

Map orientation differences between participants. ANOVA was used to determine whether there was a difference in accuracy between the four map orientation differences between participants (0°, 90°, 180°, and 270° [–90°]) in the nonidentical-map-orientation condition for the base map. No significant differences were found for accuracy, F(3, 39) = 0.974, ns, $\eta_p^2 =$.07, meaning that the size of the alignment difference was of no importance to our participants in performing the task.

Effects of map grid, compass rose, and landmarks. To test for the effects of adding extra geospatial information to maps on dyad performance, we compared the base map to maps with a rectangular grid-based spatial index, a compass rose, abstract landmarks, and combinations of map grid, compass rose, and landmarks on the basic map. First, an ANOVA was used to determine whether there was a difference between the eight map versions in the identical-map-orientation condition. This analysis revealed a significant main effect, $F(7, 91) = 3.25, p = .04, \eta_p^2 = .20$. Multiple-comparison posttests revealed that accuracy significantly increased, as compared with the base map, with the use of map grids and combinations involving map grids. No differences were found, however, between maps with map grids, a compass rose, and landmarks.

Second, an ANOVA was used to determine whether there was a difference between the eight map versions in the nonidentical-maporientation condition. A significant main effect was found, F(7, 91) = 13.52, p = .00, $\eta_n^2 = .51$. Again, post hoc testing revealed that performance significantly increased as compared with a base map when map grids and combinations using map grids were used. Moreover, it was found that dyads using map grids performed significantly better than dyads using landmarks or a compass rose. No differences were found between dyads using landmarks and those using a compass rose. When combinations were involved, all combinations gave dyads a significant advantage compared with trials in which dyads were using only a base map. Performance with combinations involving a map grid was significantly better than that with combinations without a map grid.

Dyad Performance: Task Duration

Identical versus nonidentical map orientation. For the base map, an independent *t* test was used to determine whether there was a difference in task duration between map orientation conditions when no alignment differences were present between both participants (i.e., all conditions involving a 0° difference in map rotation between participants). No significant difference was found, t(13) = -.58, ns.

Map orientation differences between participants. ANOVA was used to determine whether there was a difference in accuracy between the four map orientation differences between participants (0°, 90°, 180°, and 270° [–90°]) in the nonidentical-map-orientation condition for the base map. No significant differences were found between map orientation differences, F(3, 39) = 1.076, ns, $\eta_p^2 = .08$.

Effects of map grid, compass rose, and landmarks. A significant main effect for task duration was found for adding geospatial information to maps in the identical-map-orientation condition, F(7, 91) = 12.28, p = .00, $\eta_n^2 = .49$. Multiple-comparison posttests revealed that the map grid, landmarks, and a compass rose significantly reduced reaction time for our dyads as compared with the base map. No differences were present between dyads using a map grid and those using landmarks. Moreover, the map grid and landmarks significantly reduced the time on the task as compared with the compass rose. Combinations of map grid, compass rose, and landmarks led to faster performance as compared with trials involving only a base map. Combinations involving a map grid significantly reduced reaction times in comparison with combinations without a map grid.

An ANOVA was also used to determine whether differences were present in the nonidentical-map-orientation condition, revealing a significant main effect, F(7, 91) = 80.62, p = .00, $\eta_p^2 = .86$. Multiple-comparison posttests revealed that dyads using maps with added geospatial information performed significantly faster than dyads using base maps. Dyads using a map grid performed fastest, teams using landmarks second fastest, and dyads using a compass rose third fastest, as compared with dyads using only the base map. Again, combinations involving a map grid significantly reduced reaction times compared with combinations without a map grid.

Participant Ratings: Information Exchange

ANOVA showed a significant main effect of map orientation on information exchange, F(1, 13) = 5.094, p = .02, $\eta_p^2 = .28$. The quality of information exchange was significantly higher in the identical-map-orientation condition than in the nonidentical-map-orientation condition. Dyads reported higher levels of completeness, speed, and amount of information given and received in discussions while performing the task in identical-map-orientation blocks.

Participant Ratings: Subjective Assessment of Support Conditions

As expected, with regard to overall subjective evaluation of the map orientation conditions, there was a significant difference between conditions, F(2, 26) = 15.64, p = .00, $\eta_p^2 = .55$. Multiple-comparison posttests revealed that participants preferred maps with extra geospatial information to the base map. Moreover, participants preferred the base map with map grid (M = 6.50) to maps with compass rose (M = 5.11) and landmarks (M = 5.14). No differences were found in preference between maps with compass rose and landmarks.

DISCUSSION

The current research aimed at solving a specific problem with practical relevance: how to present information about others' locations to distributed teams. Consistent with our expectation as put forward in our first hypothesis, we found that dyads using maps with orientations that were identical for both members were more accurate in pinpointing a specific preset location on digitized maps than were dyads that used maps with differences in map orientation between members. Moreover, it was found that the quality of location-based information exchange was higher when identical map orientations were used: Dyads reported higher levels of completeness, speed, and amount of information given and received in discussions. However, our data showed no difference between both conditions for task duration. The lower accuracy of dyads using nonidentical map orientations was not accompanied by faster performance rates. This was surprising to us because in perceptual-motor tasks, there usually is a tradeoff between how fast a task can be performed and how many mistakes are made in performing the task.

For dyads using nonidentical map orientations, it was found that the magnitude of alignment differences between members was of no importance in performing the task. Differences between identical- and nonidentical-map-orientation conditions on accuracy appear to be solely the result of the extra effort that participants had to undertake in determining whether there was a difference in orientation present, not in the magnitude of difference per se. To inform each other correctly about the specific preset location on the map, both dyad members had to realize that there was a misalignment between both maps relative to each other. Then they had to figure out how it was misaligned and fix the misalignment (cf. Montello, 2005).

We learned from the debriefing sessions that most participants, when it was their turn to pinpoint the correct location on the map, first had a dialogue to identify alignment differences and then mentally rotated the map to the same position as the other participant. Of course, this poses an additional load on working memory and increases the risk of making errors. Thus, although heading-up maps clearly have benefits when it comes to individual navigation tasks, when designing for teamwork, maps that are aligned in a fixed orientation, such as north-up maps, are the better design option.

Our study is one of the first to provide evidence that specific reference points on maps allow distributed dyads to improve their teamwork. As mentioned, shared reference points provide context from which deictic reference (e.g., left, up, north, and south) is made. This helps to coordinate the teamwork and to exchange location-based information more easily. In the identical-map-orientation condition, the data revealed that accuracy significantly increased as compared with a base map when maps were completed with a map grid. Moreover, location-finding speed increased significantly as compared with the base map when maps were completed with a map grid, landmarks, or compass rose to provide for shared reference

points. However, it should be noted that only young women participated in the study, and the results should be confirmed for other gender and age combinations.

In the nonidentical-map-orientation condition, again, it was found that the addition of a map grid to a base map increased accuracy as compared with a base map without any extra geospatial information. Moreover, it was found that dyads using maps with a map grid were significantly more accurate than dyads using maps with additional landmarks or a compass rose. Dyads using a map grid performed fastest, dyads using landmarks second fastest, and dyads using a compass rose third fastest, as compared with dyads using only the base map. These findings were endorsed by the results of our subjective assessment of the support conditions. Debriefing sessions showed that map grids were superior to landmarks and compass rose. The compass rose sometimes caused problems in interpreting deictic reference to compass locations (e.g., north, south). Landmarks were occasionally confused for each other. For example, we overheard participants speaking of the blue circle when in fact the blue donut was meant. Perhaps these problems could have been alleviated with landmarks that were more distinctive or with a prior training in map reading.

Providing additional reference points to dyads having map-mediated human-to-human dialogues helps them to determine an exact location on a map. Map grids are especially effective in this context. This finding raises the question of whether the use of additional reference points on maps helps distributed teams using maps that vary in orientation between team members to perform as well as teams using maps with identical map orientations. In search for an answer to this question, we tested for interactions between map orientation and support conditions. Whereas map orientation conditions differed significantly on accuracy when comparisons were made with respect to the base map, no significant differences were found between both conditions when map versions with additional reference points were considered. This finding provides strong evidence in support of our third hypothesis. Thus, maps that vary in orientation between team members are as good as maps with orientations that are identical for all members for collaborative map location-finding tasks in distributed settings but only if these maps include geospatial information providing for shared reference points.

The present research was able to demonstrate that map orientation differences hinder map location-finding tasks between distributed team members in a controlled laboratory setting. Some might argue that the specific test setting limits the generalization of the results to the real world (for a more elaborate discussion on the criticism laboratory research has met with, see also Driskell & Salas, 1992). The task chosen in this study, however, is a generic task that is part of many higher level mapbased collaboration tasks that occur in crisis response, military, and other environments. Therefore, we believe that the results are widely applicable to other settings and populations. Still, it would be an interesting avenue for future research to extend the scope of the research beyond the laboratory and take our findings to the field and other task domains. Results from future field studies may reinforce the findings from the present work on how to provide direct support for distributed team efforts and thereby contribute to the formulation of generalizable theoretical statements (cf. Gopher & Sanders, 1984; Heuer, 1988).

An implication of this research is that geospatial systems to be used in team settings should not easily allow their users the option to change map orientation or other perspectives, such as zoom or pan functions, at will. Although most commercial products give users these options, our research shows that in team settings, these should be applied with great caution. Moreover, the results show that reaching a shared understanding through map-mediated human-to-human dialogues about specific preset locations on digitized maps is a complex and error-prone task. The implications for training are that teams should be made explicitly aware of the restraints in collaboration that are typically caused by the design of the geospatial systems to be used by the team.

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KEY POINTS

- Research on maps has been mainly directed at individuals navigating with cartographic maps. An important question is how to present information about others' locations to distributed team members.
- Dyads using maps with orientations that are identical for both members are more accurate in pinpointing a specific preset location on digitized maps than dyads that use maps with differences in map orientation between both members.
- The quality of location-based information exchange is higher when identical map orientations are used: Dyads report higher levels of completeness, speed, and amount of information given and received in discussions.
- Providing additional reference points helps distributed teams using maps that vary in orientation between team members to perform as well as teams using maps with identical map orientations.
- Navigation systems to be used in team settings should not easily allow their users the option to change map orientation or other perspectives, such as zoom or pan functions, at will. Although most commercial products give users these options, our research shows that in team settings, these should be applied with great caution.

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Rick van der Kleij is a senior research scientist in the Human Factors business unit of TNO Defence, Security, and Safety in Soesterberg in the Netherlands. His main area of interest is on making effective teams with people and collaborative technologies in collocated and distributed settings. He received his PhD in industrial and organizational psychology from the University of Amsterdam in the Netherlands in 2007.

Guido te Brake is a senior research scientist in the Human Factors business unit of TNO Defence, Security, and Safety in Soesterberg in the Netherlands. He has a special interest in control organization design, team collaboration, and support systems. He received his PhD in medicine from Radboud University Nijmegen in the Netherlands in 2000.

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