INTEGRATIVE SOCIAL PERCEPTION: INDIVIDUALS LOW IN WORKING MEMORY BENEFIT MORE FROM EXTERNAL REPRESENTATIONS

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The paper highlights the importance of looking at individual differences in working memory in order to understand complex social perceptual processes such as the construction of mental clique models from pairwise sentiment relations. We found that working memory resources constituted a limiting factor in the integrative perception of sentiment patterns (Experiment 1). Low but not high-resource individuals' performance was enhanced by use of an external memory store (Experiment 2). Finally, participants whose working memory capacity was experimentally reduced showed high correlations between use of the external store and performance. This was not the case for those whose working memory capacity was not manipulated (Experiment 3). Implications are discussed with respect to the role of working memory functions in complex social perception and the use of external memory representations in social settings.

The possible influence of individual differences in attentional resources on social cognition is as yet largely uninvestigated. Although much re-
search has addressed the role of attentional resources as a determinant of social cognitive phenomena, an individual differences approach has rarely been taken to this issue (for an overview see Conway, 2000). The research reported in this paper takes such an approach, arguing that it is important to look at individual differences in working memory resources in order to understand complex social perceptual processes. As an example of such a process, we focus on the construction of social mental models from sentiment relations. This process is examined using a stepwise information acquisition procedure in which perceivers may, in some conditions, use an external memory store after the learning stage to support model construction. The procedure is designed to investigate how the results of the constructive process are related to individual differences in working memory. We thus address individual variation in attentional resources by demonstrating the influence of such variability on constructive thinking in the domain of social perception.

In social cognition research, attentional resources are defined mainly in terms of processing speed or working memory, two conceptually related components of a common resource pool (Conway, 2000). Processing speed is studied primarily in the area of cognition and aging (e.g., Salthouse, Kausler, & Saults, 1988), whereas the present research focuses on individual differences in working memory, defined as an activated memory component in which simultaneous storage and processing functions take place and interact (Baddeley & Logie, 1999; Cantor & Engle, 1993). Working memory resources are thought to underlie most complex mental activities such as problem solving (e.g., Phillips, Wynn, Gilhooly, Della–Sala, & Logie, 1999), text comprehension (e.g., Oakhill, Cain, & Yuill, 1998), as well as many of the standard assessment tasks used to measure intelligence (e.g., Daneman & Tardif, 1987; Kyllonen & Christal, 1990). Working memory itself has been conceptualized as a system of simultaneous storage and processing that draws on a single resource pool (e.g., Just & Carpenter, 1992). As such, working memory is closely related to the resource concept used in many areas of social cognition, where researchers have focused on the different amounts of resources needed to execute various processing components in social perception tasks. For example, Fiske and Neuberg’s (1990) model of impression formation states that shallow modes of perception require fewer working memory resources and rely more on stereotypes, whereas more elaborative modes use more resources and are more detail-based. In a similar vein, Gilbert and Malone (1995) posit a first, more automatic stage of attribution, and a second, more working-memory–based stage that further elaborates the results of the first, if necessary. Dual-process models of attitude change also make assumptions about more or less effortful ways in which persuasion might function (Petty & Wegener, 1999). In most of this research, either the
availability of working memory resources or their investment by a perceiver is manipulated. For example, dual-task techniques (e.g., Gilbert, Pelham, & Krull, 1988) are used to limit the availability of working memory resources to the perception task at hand, whereas motivational manipulations (e.g., Fiske, 1993) target the perceiver’s allocation of those resources.

What distinguishes our approach from much of the work described above is that we look at the natural variation in the population with respect to working memory resources, with the aim of describing how individuals higher or lower in working memory resources behave when presented with a complex social perceptual task. Earlier research on impression formation has shown that participants with greater attentional resources recall more behaviors and cluster their recall more by trait categories than those with lower resources do (Conway, Carroll, Pushkar, Arbuckle, & Foisy, 1996). Participants high in resources also exhibit greater self-complexity and more complex representations of emotional experience than participants low in resources (Conway & White-Dysart, 1999). Furthermore, research on cognition and aging has shown that older people, who typically have fewer working memory resources at their disposal than younger people (Stoltzfus, Hasher, & Zacks, 1996), show highly selective information processing when tackling complex impression formation tasks (Hess, Follett, & McGee, 1998) and, when working on attribution tasks, sometimes mirror the performance of younger participants studied under divided attention conditions (Chen & Blanchard-Fields, 1997). It therefore seems that, generally, complex social perception is affected by individual differences in working memory resources.

The present research addresses three main issues. First, we use an experimental paradigm that allows us to define in exactly which way a social perception task is “complex.” More specifically, we focus on the step-by-step integration of piecemeal information into a comprehensive mental model. Integration, thus defined, entails exactly the type of interplay between simultaneous storage and processing that is modeled by the concept of working memory. Second, we examine an area that has not yet been extensively studied in the context of resource-dependent processing, that is, the perception of a group structure as opposed to a single target person. Third, we examined whether there is scope for low-resource individuals to engage in adaptive resource management, assuming that the integration task is more difficult for these individuals.

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1. For two examples of studies that do in fact examine the effects of cognitive capacity on group perceptions, see Kim and Baron (1988) and Rothbart, Fulero, Jensen, Howard, and Birrell (1978). However, neither of these studies took an individual differences approach, as done in the present paper.
than for those high in working memory resources. That is, we investigate how participants low versus high in working memory use compensatory means, if available, and whether the use of such means benefits one group more than the other.

With respect to the first and second issues, people dispositionally low in working memory resources can be expected to show performance limitations to the extent that social perception tasks involve integrative processing. Research has shown that, when attentional resources are limited in a dual–task condition, the resolution of inconsistencies in behavioral information provided about a target person is markedly reduced (Macrae, Bodenhausen, Schloerscheidt, & Milne, 1999). Person perception is an example of integrative thinking since individual pieces of behavioral information have to be simultaneously assessed, reconciled, and rearranged to form a coherent overall representation of the target person (Hastie, 1980; Srull & Wyer, 1989). Yet integrative thinking in social perception is not limited to forming impressions about individual others, but is also necessary when forming an impression of the sentiment structure in one’s social environment (Heider, 1958; Hummert, Crockett, & Kemper, 1990). In many social situations, particularly when entering new groups, the perceiver’s task is to form an overall picture of the group, based on a limited (usually incomplete) set of pairwise liking and disliking relations. Positive or negative sentiments are perceived to exist between individual colleagues, fellow students, or teammates. In such a situation, the aim is not only to detect subgroups or cliques that might exist on the basis of the limited information available, but also eventually to find one’s own position in the group (von Hecker, 1997). Such integrative group perception requires working memory resources. Piecemeal information about pairwise sentiments—that is, observed individual behaviors, interactive behaviors, or statements about mutual liking or disliking—must be active while, at the same time, the individual pieces of information are interrelated and coordinated in the process of integration. These two simultaneous components of maintenance and processing highlight the role of working memory (e.g., Logie, 1996; Miyake & Shah, 1999a) as the basic support system for this type of social perception. We can therefore expect the quality of integrative perception of complex patterns of sentiments in a group to be influenced by the amount of working memory resources available.

With respect to our third aim, we explore adaptive behaviors that might be observed in the case of resource limitation. Individuals low in working memory might use adaptive strategies to help them compensate for their lack of resources. Assuming a unitary pool of resources that is limited and can be flexibly allocated between the functions of maintenance and processing (Engle, Kane, & Tuholski, 1999; Fischler, 2000; Just & Carpenter, 1992), it is predicted that low-resource individuals will
profit more than high-resource individuals from the opportunity to request particular units of information from an external store during integration (Miyake & Shah, 1999b; Schönpflug, 1986). An external store may help facilitate the storage component and make it easier for low-resource individuals to concentrate their working memory resources on integration.

OVERVIEW OF THE EXPERIMENTS

In three experiments, we examine individual differences in working memory resources that might influence integrative group perception. The first experiment shows that individuals high in working memory resources construct better mental models of the sympathy structure in a group than those low in working memory resources when they are not free to work at their own pace. Experiment 2 shows that low-resource individuals benefit more from using an external representation of pairwise sentiment relations than high-resource individuals do. Finally, Experiment 3 parallels these findings using a manipulation of working memory load. Under high-load, the results from the “low” group in Experiment 2 are mimicked; that is, individuals in the high workload condition benefit more from using the external store than their counterparts in the low workload condition do.

EXPERIMENT 1

The understanding of integrative group perception was much advanced by Heider’s (1958) balance concept. This concept described how patterns of interrelated sentiment relations might be processed. Heider’s (1958) definition of balanced states among triads of persons (e.g., two friends who both like or dislike a third person) can be generalized to larger groups of persons (Hummert, Crockett, & Kemper, 1990; von Hecker, 1997), since patterns of sentiment relations among the members of the group can be represented as an integrated mental clique model. Such models represent mutual liking versus disliking between two persons by their membership of one and the same versus different mental clique(s). Consider a set of fictitious sentiment patterns such as that depicted in Figure 1. In this figure, a plus sign denotes a relation of mutual liking between two persons, and a negative sign denotes a disliking relation. Participants are presented with these relations on a computer screen one after another in a random sequence. Their task is to identify the number of subgroups among the persons presented. Given that all relations within a clique have to be positive, two possible mental clique models can be constructed from these stimuli. When the relation between persons B and F is presented as a mutual liking relation, a model representing two cliques
should result. In this case, persons A, B, E, and F should be represented in one clique, and persons C and D in another. When the relation between persons B and F is presented as mutual disliking, however, a three-clique model should result, consisting of three dyads: AB, CD, and EF. On the basis of earlier work (Hummert et al., 1990; von Hecker, 1997; von Hecker & Sedek, 1999), we can assume that people do in fact construct such comprehensive mental clique models. Thus, the main dependent variable used in this first experiment was a measure of how well the subdivision of the fictitious persons into two or three cliques was represented in participants’ memories after the learning stage.

Generally, individuals high in working memory were expected to outperform those low in working memory on the mental clique task, but particularly so when presentation times were kept constant during the learning stage.

METHOD

Participants

Sixty-four students (16 females) of natural sciences and economics from the University of Kaiserslautern participated in the experiment. Each participant received a payment of €10 (equivalent to approximately $12). Their age ranged from 19 to 67 years (M = 26).

Working Memory Measure

To assess working memory resources, the Verbal Coordination Task (VCT) developed by Oberauer (1993) was administered. This task was designed to measure coordinative and integrative functions of working memory, that is, the ability to simultaneously access several distinct elements and to coordinate them into a new, holistic, and coherent mental structure. Participants are presented with a row of boxes in the center of a computer screen. A letter is displayed in one of these boxes for 1,150 ms. Another letter is then displayed in another of the boxes. This process is repeated until a letter has been presented, participants are instructed (a) to decide whether or not the complete set of letters represents a German word (read from left to right or from right to left), and (b) to write down the letters on a response sheet showing the same number of boxes as displayed on the screen. Since only one letter is visible at a time, an internal representation of the complete stimulus array has to be constructed for the lexical decision to be made. This task requires both storage and integration re-
sources simultaneously because the participant has to (a) memorize the letters presented so far, (b) identify the stimulus letter presented at a given point in time, (c) integrate this perception into an overall representation of the stimuli already held in the memory, and finally (d) make the lexical decision. To ensure that the lexical decision is made on the basis of this internal representation and not on the basis of letters already written down on the response sheet, participants have to determine which of two available columns to use before entering the letters. One column is provided for words, and one for non-words. Fifteen items are presented, with four to eight letters each. The percentage of letters reproduced in the correct configuration, out of the total number of letters (90) across all items, is used as the performance score.

In a comprehensive study, Oberauer et al. (2000) examined the reliability and validity of this and other tasks designed to capture various functional facets of working memory. For the VCT, they reported a
Cronbach’s $\alpha$ of .84, as well as strong intercorrelations with various working memory marker tasks and with the reasoning ability component of intelligence test batteries. Moreover, Oberauer, Süß, Wilhelm, and Wittmann (2002) demonstrated that “coordination of information elements into structures” (p. 3) is a functional facet of working memory that can be empirically distinguished from “supervision” and “simultaneous storage and transformation.” With these features, the VCT is particularly suitable for measuring those working memory functions that are needed to support integrative social perception.

**Experimental Materials and Design**

Fictitious social structures of the type illustrated in Figure 1 were used. Each structure consisted of six names and eight sentiment relations. Within each structure, only names of the same gender were used. Each structure contained exactly one critical relation (between persons B and F) that determined the number of cliques (two or three). The sentiment relations were presented on a computer screen in normal size ASCII characters. *Plus* and *minus* signs were used between names to symbolize the sentiment value of the relations.

Each participant learned four different structures in random order, corresponding to four experimental blocks. Two of the structures were compatible with two cliques, that is, the relation between B and F was presented as *positive*. The other two structures were compatible with three cliques, that is, the relation between B and F was presented as *negative*. Each structure was assigned one of four different name sets (two female, two male), counterbalanced across the sample to ensure that each structure type (two vs. three cliques) was paired equally often with each name set (and therefore, gender).

Half of the participants learned the sentiment relations under fixed study times. Each relation was presented for seven seconds before the next relation appeared automatically. Participants in the other half of the sample learned the pair relations at their own pace (free study time condition).

**Procedure**

Participants read instructions on the computer screen. They were told that the task dealt with perceptions of how well people get along with one another. The instruction pointed out that upon entering a new sports team or working environment, an important goal of social perception is to find out what patterns of liking and disliking exist within the group, and how many cliques or subgroups there are. Participants were asked to view the experiment as a model of such a situation, the goal of each ex-
perimental block being to identify the most likely number of subgroups. They were told that they would be presented with a number of fictitious pairwise sentiment relationships. After this, they would be asked to give a graphical account of the subgroup structure. Participants were instructed that the experimental session consisted of four blocks. Prior to these blocks, they were given one practice trial.

**Learning.** The eight relations for each experimental block were presented such that the critical relation between persons B and F (see Figure 1) appeared at 4th, 5th, 6th, or 7th position in the sequence. Each of those four positions was randomly assigned to one of the four blocks presented to each participant, meaning that the appearance of the critical relation (BF) was unpredictable. In the fixed study time condition, participants viewed each individual relation for seven seconds. The relation sign (plus or minus) between the two names was then erased, leaving just the names on the screen, and the next relation appeared directly below. In the free study time condition, participants had to press a labeled key to proceed to the next relation. Participants were asked to memorize each relation while integrating it into an overall representation of the group.

**Clique Reconstruction.** Participants were then asked to jot down the names they had learned on a piece of paper, indicating graphically the way in which these persons could be subdivided into groups. Participants were free to choose any number of subgroups.

**Buffer Task.** A set of four easy arithmetic problems was presented to reduce short term memory carry–over effects between experimental blocks. In each item, two 2–digit numbers were to be either added to or subtracted from each other. Three solutions appeared on the screen in multiple–choice format, labeled “A” to “C.” Participants used the appropriate letter keys to select the correct answer.

Half of the participants were given the VCT to measure their working memory resources after completing the four experimental blocks, the other half took this test before the experimental blocks. Finally, participants were fully debriefed. Sessions were conducted for each participant individually and lasted about 40 minutes.

**RESULTS**

**Working Memory Measure**

The median performance score on the VCT was used to split each of the two experimental groups into subsamples of participants low and high in working memory capacity (LWM vs. HWM, see Table 1, upper panel). After the median was determined, oversampling of individual experimental conditions was conducted such that there were equal numbers of
participants ($n = 8$) who performed the VCT before and after the main task in both the LWM and the HWM subgroups of each study time condition (free vs. fixed).

**Preparatory Analyses**

First, the sequence of experimental tasks (VCT administered first vs. last) was addressed as a possible influence on the dependent variables. Median study times (free study time condition only) were determined across the four experimental blocks, for each participant and each of the eight relations in the learning sequence. Medians were used for all three experiments to reduce the influence of outliers. The medians were analyzed in an ANOVA with working memory (low vs. high), presentation position (1 through 8), and task sequence (VCT before vs. after) as factors. No effect involving task sequence was significant. The clique reconstruction score (see below) was analyzed as a function of study time condition (free vs. fixed), working memory (low vs. high), and task sequence (VCT before vs. after). It emerged that task sequence had a main effect, $F(1,56) = 5.43$, $MSE = 71.83$, $p < .02$, indicating that participants who did the VCT first performed better on the clique task ($M = 51.53$) than those who did the VCT last ($M = 46.59$). The task sequence factor did not interact with other variables, however (all relevant $p$–values $> .40$). Examining the VCT score itself, “first” participants ($M = .858$) scored marginally higher than “last” participants ($M = .823$), $F(1,56) = 2.67$, $MSE = 0.007$, $p < .10$, but there were no interactions with the task sequence factor (all relevant $p$–values $> .31$).

It appears that participants who took the VCT first performed slightly better on both the VCT and clique construction, possibly as a result of sampling error. The data do not support the assumption of task sequence per se having any specific effect. The task sequence factor is therefore not considered in the following analyses.

**Learning Stage**

Median study times (free study time condition only; determined as described above) were analyzed in an ANOVA with working memory (low vs. high) and presentation position (1 through 8) as factors. LWM participants, $M = 18,762$ ms, did not differ from HWM participants, $M = 17,002$ ms, in terms of the time spent studying each pair relation. The main effect of presentation position was significant, $F(7,210) = 12.53$, $MSE = 590,600,000$, $p < .0001$, because the eighth position required more study time than any of the others, $F(1,30) = 8.22$, $MSE = 547,612,000$, $p <$
.007 (single contrast). This contrast was significant in both groups separately [LWM: $F(1,15) = 8.04, p < .02$; HWM: $F(1,15) = 7.22, p < .02$].

### Clique Reconstruction Performance

Each participant’s assignment of fictitious persons to subgroups in each of the four blocks was scored by assessing whether it correctly reflected the sentiment information provided for each pair. For example, if a participant had placed persons A, B, and D in one and the same subgroup, they were scored one correct assignment for the AB pair, and two incorrect assignments for the AD and BD pairs (see Figure 1). The maximum obtainable score was 15 in each block. Thus, participants’ scores could
range from 0 (no correct assignments) to 60 (all 15 pair assignments correct in all four blocks).

The clique reconstruction scores were analyzed as a function of study time condition (fixed vs. free) and working memory (low vs. high). A significant main effect emerged for study time condition, $F(1,60) = 31.52, MSE = 74.60, p < .0001$, indicating that the self-paced condition generally produced more accurate reconstructions (Figure 2). As a further main effect, HWM participants performed better than LWM participants, $F(1,60) = 9.06, MSE = 74.60, p < .003$. These effects were qualified by a significant interaction of study time condition and working memory, $F(1,60) = 4.83, MSE = 74.60, p < .031$. As expected, HWM participants only performed better than LWM participants when study times were fixed, LSD test $p < .001$, and this difference was not significant when study times were free.

FIGURE 2. Mean clique reconstruction scores (Experiment 1) as a function of working memory resources (low vs. high).
DISCUSSION

When study time was fixed, high working memory participants outperformed low working memory participants on a social perception task that required the integration of piecemeal information into a coherent mental model. Whereas the cognitive operations this task requires have been studied in detail by Hummert et al. (1990) and von Hecker (1997), our focus was on the quality of the molar representation in terms of subgroups or cliques. The sequential process of construction entails the simultaneous maintenance and manipulation of piecemeal relations in order to identify the most suitable arrangement among them. Faced with these demands, LWM participants find themselves at a disadvantage.

When study time was self-paced, LWM participants did not differ from HWM participants in the quality of the mental models they constructed. For most sequential positions in the presentation series, the average study time was over 10s, that is, well over the 7-s limit used in the fixed condition. We assume that most participants used their freely chosen study times to apply individual elaborative strategies, thereby organizing and integrating the materials into coherent mental models. Both LWM and HWM participants tended to use the last presentation position for a final rehearsal of the entire structure. Despite their equal performance under self-paced conditions, it appears that LWM participants suffered disproportionately from not having this opportunity when working under fixed presentation conditions.

This first experiment may provide an initial indication of the potential value of adaptive strategies in resource management. It seems that individual differences in working memory resources do not necessarily translate into performance differences when the task leaves room for unlimited use of attentional strategies. In this study, this was demonstrated for a complex social perceptual task that generated clear performance differences when study times were limited. The argument about differential benefits of processing strategies in LWM and HWM participants can be carried further by assuming that certain types of strategies might facilitate the maintenance function in a task that taxes both maintenance and processing functions in working memory (Engle et al., 1999). Our second experiment therefore investigates the influence of an external memory store. We expect low-resource individuals to benefit more from the availability of such an aid than those high in resources.

EXPERIMENT 2

External memory representations have become an important field of research in recent years (Kintsch, Healy, Hegarty, Pennington, & Salthouse,
Individuals executing a complex cognitive task may benefit from the availability of task-relevant information from external stores (Schönpflug, 1998; Schönpflug & Esser, 1995). For example, it is easier to solve the Tower of Hanoi puzzle when some of the rules can be easily inferred from the external representation of the task itself, and thus do not have to be held in memory, than when all rules have to be represented internally (Zhang & Norman, 1994). We propose that individuals low in working memory resources might benefit particularly from external representations. In a study on the construction of mental models of mechanical devices, Hegarty and Steinhoff (1997) found the correlation between note-taking and performance (error) level to be much stronger for low working memory participants ($r = -.76$) than for high working memory participants, for whom no significant correlation was observed ($r = .09$). In another study, individuals high in test anxiety who experienced memory problems displayed a general preference for storing everyday information externally (e.g., in a note pad or a pocket diary) than for memorizing it internally (Stöber & Esser, 2001).

We believe that it is useful to extend the notion of external memory representations to the area of complex social perception. In fact, some theorists have begun to think about external stores as an extension of the working memory system beyond the limits of the individual; for example, with regard to socio-technical systems such as cockpit crews (Hutchins, 1995) or organization of group actions (von Cranach, Ochsenbein, & Tschan, 1987). In group perception, this perspective might have considerable ecological validity. Heider (1958) discussed his balance concept in the context of co-orientation between two (or more) people (see also Newcomb, 1953), the notion being that communicative acts serve to construct and maintain a coherent set of viewpoints, preferences, and attitudes in the presence of others. We suggest here that, in the context of sentiment perception, a group that we find ourselves part of may well be regarded as a communicative resource in the sense of an external memory store. For example, when meeting every week, members of a newly formed group have repeated opportunities to update their knowledge about mutual liking or disliking sentiments within the group. They can do so by making repeated intentional observations about interaction patterns, or quite explicitly by asking someone about their sentiments towards a third person. By updating piecemeal information in this manner, individuals may further their attempts to construct a comprehensive mental model of the liking structures within the group as a whole. At later stages of group development, the mnemonic and communicative strategies used in these attempts may lead to the formation of interpersonal strategies and behavioral patterns that promote transactive memory (Wegner, 1987; Wegner, Erber, & Raymond, 1991). These are issues beyond the scope of the present paper; neverthe-
less, the point to be made here is that the availability of an external memory store in a situation of initial sentiment perception might be of benefit to those low in working memory resources.

In Experiment 2, we therefore simulated the availability of an external representation of individual sentiment relations in the laboratory. After learning an initial, reduced pattern of relations (AB, CD, EF, BD, and DF only, see Figure 1), participants entered a second stage, in which they had the opportunity to ask for further relations of their choice to be displayed. However, we varied the diagnostic value of the relations that could be requested. Relations BF, AE, AF, and BE (see Figure 1) are of maximal diagnostic value because they discriminate between the two types of mental model (two or three cliques). Therefore, these four relations are called diagnostic relations. The diagnostic value of relations such as AD or DE is intermediary, since the relation cannot disambiguate the whole structure, although it can establish a cognitive triad (Heider, 1958)—for example, ABD or DEF—and thereby clarify the upper or lower part of the structure (see Figure 1). Relations AD, BC, DE, and CF are therefore called partly diagnostic. The remaining relations (AB, CD, EF, BD, DF, AC, CE) are of no diagnostic value at all.

We predicted that LWM individuals would benefit more than their HWM counterparts from repeated use of the request option, since the use of an external memory store would free up working memory to process the piecemeal relations. In contrast, HWM individuals’ performance was expected to be unrelated to the number of relations requested in the second stage, because their larger attentional resources should allow them to execute the integration and support the active maintenance of piecemeal relations at the same time. Therefore, whether a particular piecemeal relation is displayed once or several times should not make much difference to their performance level.

Since participants knew that they could request additional information in the second stage and that they had ample opportunity to back up their knowledge even after the proper learning stage, we did not expect the differential use of self-paced study time observed in Experiment 1 to be repeated in this study. Likewise, we did not expect the last presentation position to be associated with the same marked increase in study time as was the case in Experiment 1.

METHOD

Participants

Thirty-eight undergraduate students (29 females) enrolled in psychology and educational science at the Free University of Berlin participated
in the experiment. Their age ranged from 20 to 42 years \((M = 26)\). Psychology students participated for course credit, while educational science students received € 7.50 (equivalent to approximately $9) for participation.

**Working Memory Measure**

The same task as in Experiment 1 (VCT, Oberauer, 1993) was used to divide the sample into subsamples with low versus high working memory resources by median split (see Table 1, middle panel).

**Experimental Materials and Design**

Fictitious social structures similar to those in Figure 1 were used. However, only five relations (AB, CD, EF, BD, DF) were presented in the first stage of the experiment. Each participant was presented with four different structures in random order, corresponding to four experimental blocks. Two of the structures were designed as compatible with two cliques, the other two as compatible with three cliques. Each structure was assigned one of four different name sets (two feminine, two masculine) systematically across the sample to ensure equal frequencies in assignments between names and gender.

**Procedure**

Participants read instructions on the computer screen. In the first stage of the experiment, these instructions were identical to those used in the learning stage of Experiment 1. In particular, the same self-paced presentation method was used. However, participants were instructed that after initial learning, they would enter a second stage, in which they would be able to complete their impression of the group by requesting further information on the relations. It would be possible to review relations from the initial learning stage or to request new information on the relations between any person pair they might specify. After this request stage, they would be asked to indicate the number of subgroups they perceived to exist among the persons presented.

During the request stage, participants were presented with a list of all six persons on the screen. Each person was assigned a number (1–6). Participants were instructed to type in two numbers, corresponding to any pair they wished to view. The requested pair was then displayed on the screen until the participant pressed the space bar. The next request could then be made in the same way. The screen was refreshed for each new request, such
that previous requests were no longer visible. Each participant had a maximum of 40 request options available in each block (none of the participants reached this maximum limit). Participants indicated that they had gathered enough additional information by pressing a marked key. The question as to the number of subgroups was then displayed on the screen. The response format allowed participants to enter any integer number, including zero.

The four blocks were separated by a buffer task. Before tackling the blocks, participants were given practice trials on the procedures of the two stages. All other presentation and randomization procedures were the same as in Experiment 1. The VCT was administered to measure participants’ working memory resources after they had completed the four experimental blocks. Participants were then fully debriefed. Sessions were conducted for each participant individually and lasted about 50 min.

RESULTS

Learning Stage

Median study times were determined for each participant and each of the five relations in the learning sequence. These medians were analyzed in an ANOVA with working memory (low vs. high) and presentation position (1 through 5) as factors. The two groups exhibited similar mean study times of 11,097 ms (LWM) and 11,520 ms (HWM) per relation. The main effect of presentation position was significant, $F(4,144) = 14.14, MSE = 96,770,000, p < .0001$, with an increasing linear trend across the five presentation positions. This trend was significant for both LWM ($p < .01$) and HWM ($p < .001$) participants. The interaction of working memory and presentation position was not significant.

Request Stage

Participants in the two memory groups did not differ in the mean number of requests made across all four blocks [$M$(LWM) = 26.68; $M$(HWM) = 28.92]. The number of requests did not correlate with study times. Furthermore, there was no between-group difference in the mean number of requests made for the different types of relations (non-diagnostic, partly diagnostic, and diagnostic), so the numbers of requests could be summed across these categories.

With respect to judgments about the number of subgroups, when summed across all four experimental blocks, LWM participants showed a slightly lower mean number of correct responses ($M = 3.11$) than HWM
participants \((M = 3.42)\). However, this difference was not significant, \(t(36) = -1.18; p = .24\).

Next, we examined the extent to which the number of requests predicted performance. The total number of requests correlated with the subgroup judgment score. As expected, LWM participants exhibited a high positive correlation, \(r = .68\) \((n = 19, p < .001)\), whereas there was no such correlation for HWM participants, \(r = .09\) \((n = 19, p = .35)\). The difference between these two coefficients was significant, \(p < .02\) (the variances in the two variables did not differ significantly between the two groups). In other words, requesting additional information on relations in the second stage substantially enhanced the performance of low-resource individuals, but not that of high individuals. At a more fine-grained level, correlations between subgroup judgment and number of requests for relations of different types were examined (Table 2). As predicted, substantial coefficients emerged only in the LWM, and not in the HWM group.

DISCUSSION

Consistent with our hypothesis, individuals low in attentional resources benefited more from the availability of external representations while executing an integrative social perception task than those high in attentional resources. High-resource individuals were presumably better able to simultaneously address storage and processing demands (Baddeley, 1986). Interestingly, LWM individuals profited most from repeated inspection of those pieces of information with the highest diagnostic value.\(^2\) This result is in line with research on text comprehension (King & Just, 1991) showing that participants low in working memory concentrate more on highly diagnostic than on non–diagnostic parts of a sentence, whereas this difference was not so pronounced in a high working memory group. Moreover, the two overall correlation coefficients found in the two groups (LWM: \(r = .68\); HWM: \(r = .09\)) closely parallel the magnitudes of correlations found by Hegarty and Steinhoff (1997) for their samples of low vs. high-resource participants. In their study, amount of note–taking was used to mea-

\(^2\) Although this observation is interesting at a descriptive level (cf. Table 2), it should be noted, first, that the correlations do not differ significantly from each other and, second, that all three request variables in Table 2 (ND, PD, and D) are highly correlated among themselves in both groups (coefficients ranging between .78 and .94). The same holds for the three variables observed in Experiment 3, for both low-load and high-load groups. Thus, it might be more parsimonious to assume a single request dimension in both studies.
sure access to external memory stores, whereas in our experiment, the availability of information on mutual sympathy was simulated. Despite these differences, both studies shed light on the role that external representations may play in the integrative thinking of low vs. high-resource individuals.

There is another important parallel between our research and the work of Hegarty and Steinhoff (1997). In their data, the working memory measure did not predict the amount of note-taking. Assuming that low-resource individuals are aware of their weakness and behave adaptively, such a correlation would be expected. Likewise, our data show that LWM and HWM participants tend to make similar numbers of requests for further information, and there was no correlation between working memory resources and use of the external memory store. This also holds when the correlations are calculated separately within groups (\( r = –.03, \text{ns} \) and \( r = .20, \text{ns} \) for LWM and HWM respectively). These findings from both lines of research suggest that the use of the external memory store is supported by metacognitive abilities that are themselves independent of attentional resources. Metacognitive abilities may have enabled some of the participants in the LWM group to use the external store strategically. Presumably as a result of this, the groups did not differ statistically in their levels of performance. Conversely, the metacognitive skills of participants in the HWM group might also vary, and they might not all have realized that repeated requests were essentially inefficient for them.

<table>
<thead>
<tr>
<th>Type of Request</th>
<th>LWM (Exp. 2)</th>
<th>HWM (Exp. 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ND</td>
<td>.62**</td>
<td>.09</td>
</tr>
<tr>
<td>PD</td>
<td>.68***</td>
<td>.08</td>
</tr>
<tr>
<td>D</td>
<td>.75****</td>
<td>.19</td>
</tr>
<tr>
<td>Type of Request</td>
<td>LWM (Exp. 3)</td>
<td>HWM (Exp. 3)</td>
</tr>
<tr>
<td>ND</td>
<td>.42**</td>
<td>.16</td>
</tr>
<tr>
<td>PD</td>
<td>.45**</td>
<td>–.02</td>
</tr>
<tr>
<td>D</td>
<td>.52***</td>
<td>.06</td>
</tr>
</tbody>
</table>

Note. One–tailed tests: *\(p < .05\), **\(p < .01\), ***\(p < .001\), ****\(p < .0001\). LWM/HWM: low/high working memory resources (median split). High/low load: request stage with/without concurrent task. Type of relation requested: ND = nondiagnostic (AB, CD, EF); PD = partly diagnostic (AD, BC, CF, DE); D = diagnostic (AE, AF, BE, BF). Subgroup judgment: Number of correct judgments of the number of cliques.
EXPERIMENT 3

In a third study, we applied a mental workload manipulation to experimentally create a condition of limited resources, and thus link the interpretation of the findings from Experiment 2 more directly to working memory. Dividing samples by median split has the disadvantage that the grouping variable may be confounded with variables other than working memory capacity that might interact with the experimental task, such as spatial ability or general intelligence. If a limitation of working memory resources is indeed responsible for the high correlations observed, then substantial correlations between request behavior and performance, as observed for the LWM group in Experiment 2, should also be obtained for the high-load group in this study, who have an artificial limitation imposed on their working memory resources. On the other hand, low-load participants should exhibit significantly lower correlations of this type. Experiment 3 was a replication of Experiment 2 with the exception that, instead of a median–split design, a random experimental design was used to create a low-load and a high-load condition.

METHOD

Participants

Sixty-eight students (49 females) enrolled in undergraduate psychology courses at Cardiff University participated in the experiment. Their age ranged from 19 to 22 years ($M=20$). They were given academic credit toward their introductory courses for participation.

Experimental Materials and Procedure

All materials were essentially the same as in the second experiment, with the exception that English first names were used instead of German ones, and that an English version of the VCT was used to measure working memory capacity (see Table 1, lower panel). Procedures were the same as in Experiment 2, with the exception that, in the high-load condition, backward counting was introduced during the request stage as a concurrent task to tax working memory resources (Baddeley, 1986; Smyth & Pelky, 1992). Participants were asked to count backwards aloud upon a start signal, beginning with a 3-digit number. The number was presented concurrently with any requested relation, appearing two lines below that relation. Participants were instructed to start counting downward, while at the same time memorizing and in-
tegrating the sentiment relation displayed. Each requested relation was presented for 5 s.

The VCT was administered after the four experimental blocks had been completed, to provide descriptive information about participants’ working memory resources relative to the first two experiments. Participants were then fully debriefed. Sessions were conducted for each participant individually and lasted about 50 minutes.

RESULTS

Preparatory Analyses

Low-load and high-load groups did not differ in terms of the working memory measure (see Table 1).

Learning Stage

Median study times were again determined across the four experimental blocks, for each participant and each of the five relations in the learning sequence. These medians were analyzed in an ANOVA with workload (low vs. high) and presentation position (1 through 5) as factors. The groups showed slightly shorter mean study times as compared to Experiment 2, that is, 7,188 ms in the low-load condition and 6,547 ms in the high-load condition; the two conditions did not differ significantly from each other, $F < 1$. The main effect of presentation position was significant, $F(4,264) = 20.71, MSE = 12,450,000, p < .0001$, again due to an increasing linear trend across the five presentation positions that was significant for low-load and high-load participants (both $p s < .001$). The interaction of working memory and presentation position was not significant.

Request Stage

During the request stage, low-load participants made more requests ($M = 41.4$) than high-load participants ($M = 25.3$), $t(66) = 3.16, p < .002$. The number of requests did not correlate with study times. In terms of correct subgroup judgments, low-load participants performed at a markedly higher level ($M = 3.23$) than high-load participants ($M = 2.41$), $t(66) = 3.55, p < .001$, although the high-load condition was still above chance level (two correct subgroup judgments out of four), $t(33) = 2.36, p < .02$. Performance levels in the low-load condition were similar to those observed in Experiment 2. With respect to our main hypothesis, the corre-
lations between the total number of requests and the subgroup judgment performance score were \( r = .08 \) in the low-load condition and \( r = .47 \) in the high-load condition, which is a statistically significant difference, \( p < .04 \) (one-tailed). The variances in the two variables did not differ significantly between the two conditions. Under high working memory load, participants benefited from the requests they made substantially more than under low-load.

As shown in the second line of Table 2, high-load participants’ request behavior for particular types of relation increased numerically as a function of request diagnosticity, although the differences between these coefficients are clearly not significant. The pattern in the high-load group parallels the findings obtained for the LWM group in Experiment 2 without the additional working memory load. For low-load participants, however, there were low correlations across all types of relations.

DISCUSSION

The high-load manipulation created an experimental condition that was more difficult and presumably less attractive as a task, as reflected in participants’ lower persistence in making requests in the high-load condition than in the low-load condition, as well as in the lower performance level that may have resulted from these less frequent requests. However, with respect to our main hypothesis, Experiment 3 provided a clear replication of the substantial correlations between molar representation and request behavior in a low-resource condition, this time using an experimental variation of working memory load. Parallel to the findings from Experiment 2 with individuals dispositionally low in working memory, participants whose working memory capacity was experimentally reduced benefited significantly more in the present experiment from the availability of an external store than their counterparts whose working memory capacity was not manipulated. Use of the external store most likely frees up working memory resources that can then be used for integrative purposes. The overall magnitude of the correlations between requests and performance is lower than observed in Experiment 2 (given that the low-load sample constitutes an unselected mixture of LWM and HWM individuals), but the point to be made is that a difference between the two correlations was obtained for the two experimental groups.

The pattern from this third study corroborates the view that the substantial correlations in fact reflect individual differences in attentional resources. The results make it less likely that the different correlational patterns found between groups in Experiment 2 could be attributed to between-group differences in general intelligence or in more specialized skills such as spatial abilities. Thus, we conclude that working
memory resources constitute a limiting factor in the integrative perception of sentiment patterns in groups, and that individuals’ performance on this task can be aided by the use of an external memory representation, whether these individuals are low in working memory resources for natural or for artificial reasons.

In terms of model construction performance, the quality of molar representations obtained in the high-load condition was clearly lower than under low-load, or in Experiment 2, or in the free study time condition in Experiment 1. As such, the construction of a clique model from pairwise sentiment relations is substantially hindered by dual–task conditions. Because the concurrent task coincides with the presentation of each individually requested relation, the additional memory load occurs at exactly those times in which model construction is likely to occur.

As in Experiment 2, there were only weak, and not significant correlations between working memory resources and use of the external memory store (low-load: \( r = -0.30, \text{ns} \); high-load: \( r = 0.24, \text{ns} \)). To the extent that metacognitive abilities might have guided the use of the external store (see Hegarty & Steinhoff, 1997), those abilities were only weakly related to working memory resources.

**GENERAL DISCUSSION**

The series of experiments reported here takes an individual differences approach to addressing the role of working memory resources as a determinant of performance in an integrative social perception task. The impact of individual differences in attentional resources on social perception is still a relatively neglected area (see Conway, 2000, for an overview). Individuals low in attentional resources appear to be disadvantaged in various social perception tasks (Chen & Blanchard–Fields, 1997; Conway et al., 1996; see also von Hecker, Dutke, & Sedek, 2000), or to exhibit less effortful modes of processing (Fiske, Neuberg, Beattie, & Milberg, 1987). We argue that influences of individual variability in working memory resources should be most prominent in tasks with integrative demands, that is, tasks requiring active maintenance of piecemeal information at the same time as manipulation and rearrangement of these elements. As an example of such a task, we focused on the construction of mental clique models from pairwise sentiment relations (Hummert et al., 1990; von Hecker, 1997).

In a first experiment, we found that working memory resources did constitute a limiting factor in the integrative perception of sentiment patterns. High-resource participants performed better than low-resource participants in a fixed–presentation condition. In a second experiment, we found that LWM individuals’ performance on the same task was substantially enhanced by their use of an external memory store,
whereas HWM individuals' performance was not. In a third experiment, these results were paralleled by an experimental approach in which a limitation in attentional resources was manipulated in a dual–task design. The data from Experiments 2 and 3 show clear differences between LWM and HWM participants, not in the quantitative use they make of the external store, but rather in the effectiveness of its use. In evaluating the three experiments in a wider context, we go on to discuss some more general implications that this line of research may have for the understanding of individual differences in social cognition and the use of external memory stores.

One way of understanding the substantial magnitude of correlations when resources are limited (LWM group in Experiment 2 and high-load group in Experiment 3) is to assume that, given the availability of an external store, participants prioritized the coordinative function of working memory (for the separability of coordinative functions and storage–related functions in working memory, see Miyake, Friedman, Emerson, Witzki, Howerton, & Wager, 2000; Oberauer, Süß, Schulze, Wilhelm, & Wittmann, 2000; Oberauer, Süß, Wilhelm, & Wittmann, 2002). Since participants knew they could redisplay any relation later on, fewer resources from the limited pool needed to be allocated to storage, meaning that the external support proved useful for them. On the other hand, since their resource pool was larger, HWM individuals in Experiment 2 and low-load participants in Experiment 3 were able to allocate enough resources to the storage function in the first place, meaning that the external support was of no additional benefit to them. This interpretation is consistent with the concept of a unitary pool of attentional resources as proposed by Just and Carpenter (1992) or Engle et al. (1999).

A consequence of the unitary view in the working memory literature was to assume more generally that as storage demands increase, there are fewer resources available for coordination, and vice versa (Daneman & Carpenter, 1980). An alternative view proposes that executive processes and information maintenance processes are supported by separate components of working memory (e.g., the central executive and the phonological loop, see Baddeley, 1986). In support of this latter view, increasing storage demand (memorization of words) has been shown to have no impact on the capacity for arithmetic verification and vice versa (Baddeley & Logie, 1999). An important difference in approach, however, is that the materials designed to tax different subpools of resources were unrelated (arithmetic problems vs. words), whereas in the present experiments, both functional components—storage and coordination—focused on the same set of materials throughout (sentiment relations). This difference is important since it makes a unitary pool explanation more viable for the present results.
That is, although there may be different resource pools that would contribute to complex tasks involving different modalities and materials, it is more parsimonious to assume a single pool of resources when storage and coordination focus on the same target stimuli. As a caveat, one should note that our working memory measure was specifically designed to capture the coordinative function (Oberauer, 1993), and that the effects observed here may thus be specifically tied to individual differences in resources that support this function, and may not necessarily reflect the effects of working memory resources in a broader or more comprehensive sense.

Some more general issues arising from the present findings concern adaptive behaviors that may be adopted in the case of resource limitations. We have presented evidence to show that individuals low in working memory resources benefit more from external memory representations than those high in such resources. Although this finding is new in the context of social perception, it is not new in other areas. Hegarty and Steinhoff (1997) found analogous results in the area of mechanical understanding and note-taking. Note-taking may help to decompose a complex mechanical problem into simpler sub-units that can be looked at sequentially. It can also alleviate the task of maintaining intermediate results in working memory. Based on evidence that high test anxiety is associated with working memory problems (for reviews see Eysenck, 1979, Mueller, 1992, Zeidner, 1998), Stöber and Esser (2001) studied the effort that high and low anxiety individuals make to remember everyday tasks such as wanting to call a friend next Monday. Individuals high in test anxiety generally preferred external stores over their own memory, independent of the importance of the information to be remembered.

The effective use of such supportive devices requires metacognitive skills, that is, an understanding about when to store information externally as well as an insight into the overall costs and benefits of using external memory devices. In other words, the benefits of easing the load on working memory should outweigh the costs of learning and remembering how to use the device itself (Schönpfug, 1998; Schönpfug & Esser, 1995). These metacognitive abilities appear to be only weakly correlated to attentional resources. In Hegarty and Steinhoff’s (1997) sample, some of the low working memory individuals took notes whereas others did not. Likewise, in Experiments 2 and 3 of the present research, working memory resources were not significantly correlated with the number of requests made. Thus, it appears that being disadvantaged in complex cognitive tasks is not automatically associated with increased use of external memory, even though the benefits of such behavior would be substantial.

In social cognition research, these issues have not previously been addressed from an individual differences perspective. However, research
on external memory itself is increasing. The use of external stores has been studied in applied social-cognitive settings such as organization of group action (v. Cranach et al., 1987) or ergonomic cockpit designs that take into account the exigencies of communication between crew members (e.g., Hutchins, 1995). The concept of transactive memory (Wegner, 1987; Wegner, Erber, & Raymond, 1991) also relates to the notion of metacognitive abilities discussed above, as transferred to an interindividual level. Information may be distributed among members of groups and within close relationships, whereby encoding, retrieval, and communication of information from different domains of specialization is relegated to specific individuals within the group or dyad. The effective use of such a complex memory system that transcends the boundaries of the individual relies on developed, effective patterns of interaction (Bangerter, 2002) and a sense of interdependence between the individuals involved (Hollingshead, 2001). We propose that individuals low in attentional resources, to the extent that they possess pertinent metacognitive skills and engage in corresponding behavior, will draw particular benefit from transactive memory settings. A study with elderly couples showed that those who engaged in transactive memory activities as part of their daily routine performed better in a criterion memory task (Johansson, Andersson, & Roenneberg, 2000). These couples had developed social skills that helped them to ease each other’s memory load by externalizing part of the information to be remembered. Since elderly people are assumed to have limited attentional resources (Salthouse, 1992), these findings may underscore the point that we want to make here, which is that low-resource individuals are especially likely to benefit more from the availability of external memory stores.

Groups may also be viewed in terms of external memory stores, for example, in situations when new working teams form, or when people move house and find themselves in a new neighborhood and leisure context. New group members may engage in repeated observations or inquiries to find out about social affiliations, mutual sympathy structures, and factions within the larger group, and thus support and update their individual mental models of the social environment as a whole. The present research may stimulate new ideas about the possible influence of individual differences in attentional resources on these more dynamic processes in groups. Depending on the attentional resources and metacognitive skills available, individuals may initiate and pursue such activities in different, but perhaps predictable ways. Future research should address the interplay of attentional resources and the development of social interactions in newly formed groups.
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SOCIAL PERCEPTION AND EXTERNAL REPRESENTATIONS


