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Sleep Deprivation Impairs and Caffeine Enhances My Performance, but Not Always Our Performance: How Acting in a Group Can Change the Effects of Impairments and Enhancements

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Abstract

What effects do factors that impair or enhance performance in individuals have when these individuals act in groups? We provide a framework, called the GIE ("Effects of **G**rouping on **I**mpairments and **E**nhancements") framework, for investigating this question. As prominent examples for individual-level impairments and enhancements, we discuss sleep deprivation and caffeine. Based on previous research, we derive hypotheses on how they influence performance in groups, specifically process gains and losses in motivation, individual capability, and coordination. We conclude that the effect an impairment or enhancement has on individual-level performance is not necessarily mirrored in group performance: grouping can help or hurt. We provide recommendations on how to estimate empirically the effects individual-level performance impairments and enhancements have in groups. By comparing sleep deprivation to stress and caffeine to pharmacological cognitive enhancement, we illustrate that we cannot readily generalize from group results on one impairment or enhancement to another, even if they have similar effects on individual-level performance.

Keywords

group processes, group performance, process gains, process losses, impairment, enhancement, sleep deprivation, caffeine, stress, pharmacological cognitive enhancement, neuroenhancement

"Two heads are better than one." This popular saying reflects the general assumption that working together in a group is beneficial to achieve high performance. And, indeed, companies and institutions rely on teams to be functional and competitive (e.g., Surowiecki, 2004; Swezey & Salas, 1992). The more challenging the economic, political, military, or medical issue that has to be resolved, the more likely it is that a group of people will be employed to work on it. This trend to rely on *group performance* seems to be so strong that our era has been labeled an "age of groupism" (Locke et al., 2001, p. 501). Accompanying this societal trend is vast research interest in groups as entities in general (e.g., Baumeister, Ainsworth, & Vohs, 2015) and in group performance in particular (e.g., Bahrami et al., 2010; Kerr & Tindale, 2004; Koriat, 2012). For many years, research has been identifying factors that can increase or decrease group performance—claiming to explain dramatic failures of real life groups and to offer practical advice on how to help groups bring about optimal results (e.g., Hackman & Morris, 1975; Janis, 1982).

The 24/7 Lifestyle

Besides the prevalence of work groups in all areas of society, we can also see a rise in what we could call a "24/7 lifestyle": For diverse reasons, efficiency demands are growing, and more and more people worldwide work long hours and in shifts regardless of the time and day (McMenamin, 2007). This 24/7 lifestyle has direct adverse consequences for individuals, in particular *sleep deprivation.* Insufficient sleep is so common nowadays (e.g., Schoenborn & Adams, 2010) that it has been claimed to be a "public health epidemic" by the U.S. Centers for Disease Control and Prevention (2015). Similarly, as one means of coping with the 24/7 lifestyle, the intake of *caffeine* is on the rise. Caffeine is the world's most widely used psychoactive substance, being consumed daily mainly in coffee, cola beverages, or tea by a large (~80%) and growing portion of the U.S. population (Einöther & Giesbrecht, 2013; Frary, Johnson, & Wang, 2005).

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Research on Group Performance in Times of a 24/7 Lifestyle

Both sleep deprivation and caffeine have been shown to have a profound impact on human performance. Whereas sleep deprivation acts as a performance *impairment* overall (for a review, see Alhola & Polo-Kantola, 2007), caffeine can act as a performance *enhancement* (for a review, see Einöther & Giesbrecht, 2013). Both factors are common in work contexts, and many workers who follow a 24/7 lifestyle do their work in groups. Think, for example, of the many occupations that require people to work together for many hours, including nights, like firefighters or emergency medical teams, or of far-ranging political and economic decisions that are made by committees while drinking several cups of coffee. Hence, it is surprising that there is so little empirical research examining the influence of sleep deprivation and the influence of caffeine on performance when people act in groups, especially because applicability has often been a central goal of group performance research.

As a first attempt to address this issue, in this article, we offer a conceptual analysis of how sleep deprivation and caffeine can influence performance in groups. By doing this, we aim to not only take a first theoretical step in understanding the effects of these two specific factors but also provide a general framework for research. This framework can serve as a model for how to tackle the question of how factors that are known to impair or enhance individual performance might be expected to affect performance when the individuals act in groups. We call it, hence, the "Effects of **G**rouping on **I**mpairments and **E**nhancements" framework, or simply, the GIE framework. Reading this, you might ask, "can't we just rely on findings on how individuals perform under sleep deprivation and under caffeine to know how they will be affected when working in a group?" We would answer that we cannot. To use an illustration, just because we know that a tipsy individual performs worse than a sober one, a tipsy group does not necessarily perform worse than a sober group. For example, it has been shown that groups can compensate for their members' alcohol induced impairment of several aspects of cognitive functioning (Frings, Hopthrow, Abrams, Hulbert, & Gutierrez, 2008; cf. also Abrams, Hopthrow, Hulbert, & Frings, 2006). As we explain in detail below, we generally cannot simply presume that effects on individual performance are mirrored in group performance, as group performance is affected not only by the capabilities of the individual group members but also by the social processes that the group uses to match those capabilities with the demands of its task.

Our article has three main parts. First, we present an overview of group performance research, with a focus on how best to estimate group performance from individual performance. Second, we provide a general introduction to research on the effects of sleep deprivation and caffeine on individual performance and analyze how they should influence different aspects of performance in groups. Third, we further illustrate our GIE framework for analyzing how acting in a group influences the effects of individual-level performance impairments and enhancements. Here, we also discuss the generalization of findings from one impairment or enhancement to another, using the examples of stress (as an impairment) and pharmacological cognitive enhancement (as an enhancement), and we consider the role of task characteristics, group size, and diversity in group composition as moderating variables.

Performance in Groups

Potential and Actual Group Performance

Imagine the following situation: In a small company, a slogan to advertise a new product is needed. It is likely that the "creative team" will come together and think about a slogan. The management's hope is that this mutual brainstorming (Osborn, 1957) results in a more successful slogan than would be obtained by asking each member of the team separately to produce an advert. Obviously, the underlying assumption is that working together in a group is beneficial in terms of increased performance. However, it is not that simple. A group's performance need not be equal to the sum of its members' task capabilities.

Inspired by Ivan Steiner's (1966, 1972) influential work on group processes and productivity, different conceptualizations of group performance have been suggested (e.g., Hackman, & Morris, 1975; Larson, 2010). One (Schulz-Hardt & Brodbeck, 2015) suggests that group performance is determined by (a) *individual-specific* components, and (b) *group-specific* components. In this conceptualization, the individual-specific components reflect the task competence and motivation each individual group member can contribute to the group's performance. The group-specific components refer to the group dynamics (cf. Lewin, 1947)—all influences of social interaction and social interdependence that occur within the group. It is the group-specific components that determine whether a group falls short of, achieves, or even exceeds the performance that one might expect from the individual-specific components. Therefore, it is essential in group performance research to assess these group-specific components. To do so, some benchmark must be computed—the so-called *group potential.*

There have been many such group potential baselines suggested, including the performance of the group's best member (e.g., Larson, 2010; Lorge & Solomon, 1955; Restle & Davis, 1962), the performance of the average group member (e.g., Larson, 2010), and the sum of individual performances (e.g., Ringelmann, 1913). One of Steiner's (1972) insights was that the potential of the group fundamentally depends on the demands of the particular task the group is faced with. He envisioned an idealized *potential productivity* baseline, which would assume that group members are no less motivated than when working alone and that the group optimally combines and coordinates the members' resources (e.g., task relevant skills, abilities, and knowledge) given the particular demands of the group's task. This is a very useful concept, at least in the abstract. One can take the difference between the group's potential productivity and its *actual productivity* as an estimate of the group's sub-optimality, what Steiner called *process loss*, and then further analyze it to identify instances of suboptimal motivation (or *motivation losses*, for example, Karau & Williams, 1993) or of suboptimal coordination (or *coordination losses*, for example, Stroebe & Diehl, 1994). But sometimes, it can be difficult to specify precisely what a group's potential productivity is. One complication is that people can be more highly motivated when working in a group than when working individually (e.g., Kerr & Hertel, 2011; Williams & Karau, 1991), something that was not clearly anticipated in Steiner's model. Another is that it can be hard to specify just what the group is capable of. It is conceivable that group interaction may result in capabilities that could not easily be estimated from knowledge of individual capabilities. For example, someone making an error of reasoning may be less able to recognize it as an error than another group member who has not made it (Shaw, 1932), or complex solution strategies that are beyond the understanding of any single individual might be cobbled together from the combination and elaboration of less complex strategies that individuals do possess (e.g., Laughlin, Carey, & Kerr, 2008). Hence, there may be more than one reasonable way of defining a group's potential productivity, and some confusion can occur depending on which baseline is chosen—one researcher's evidence for group sub-optimality can be another researcher's evidence for group super-optimality. For these reasons, we think the most useful baselines should (a) explicitly take the group's task demands into account, (b) be based on what one can observe among individuals, and (c) make minimal assumptions about group social processes. The third requirement helps ensure that deviations from the baselines can be attributed to interesting social processes, that is, group-specific components.

This line of reasoning leads us to recommend the *nominal group potential* as a particularly informative baseline. This is the performance a group would achieve if no group interaction took place that could inhibit or facilitate the group's productivity, and if the performances of individual group members were aggregated or combined in a way that was optimal for the task at hand (e.g., summed for most repetitive production tasks or selecting the best individual performance for a non-divisible Eureka task[1]). Essentially, the nominal group potential is the performance of a group that would have occurred if its members had worked at the same task independently of each other, and those independent performances had been optimally combined.

The nominal group potential of our exemplary creative team is the number of non-redundant ideas for a slogan generated by the same number of people working individually without interacting. In this conceptualization, whenever the actual group performance exceeds the nominal group potential, some group-specific *process gains* were responsible, whereas, whenever groups do not reach their potential, some group-specific *process losses* were responsible (cf. Schulz-Hardt & Brodbeck, 2015). This can be expressed in the following simple formula (Hackman & Morris, 1975): Actual Group Performance = Group Potential − Process Losses + Process Gains.

Three Sources of Process Gains and Losses: Motivation, Individual Capability, and Coordination

Over the last decades, group performance scholars have been investigating many of the factors that underlie process gains and losses (e.g., Diehl & Stroebe, 1987; Ziegler, Diehl, & Zijlstra, 2000). Process gains and process losses can be conceptualized as arising from three different sources: (a) *motivation*, (b) *individual capability*, and (c) *coordination* (Schulz-Hardt & Brodbeck, 2015). First, working together in a group can either increase (e.g., Kerr & Hertel, 2011) or decrease (e.g., Karau & Williams, 1993) the group members' motivation to put effort into the mutual task. To return to our example, motivation gains might occur, for instance, when individual members of the creative team increase their individual effort to compensate for deficits of other team members (i.e., "social compensation"; Williams & Karau, 1991). Motivation losses, however, could also occur, for example, when individual members of the creative team feel that their own contribution has little impact on the group's overall performance and therefore reduce their effort ("dispensability effect"; Kerr & Bruun, 1983). Second, the group setting can functionally lead to gains or losses in individual capability; that is, the individual group members' ability to perform on the task at hand. For example, an idea for a slogan mentioned by one member of the creative team might stimulate a cognitive category that the other group members would not have thought of otherwise ("cognitive stimulation"; for example, Kohn, Paulus, & Choi, 2011; Nijstad, Stroebe, & Lodewijkx, 2002; Paulus & Yang, 2000). On the contrary, an idea for a slogan contributed by one member of the creative team might make the others focus on the category this idea belongs to, leading to the neglect of other categories ("cognitive restriction"; for example, Kohn & Smith, 2011). Third, the social interaction within the group can lead to coordination losses if the group members do not coordinate their individual contributions in an optimal way. For example, while one member of the creative team is talking, others cannot think about or at least cannot mention their ideas ("production blocking"; Diehl & Stroebe, 1987; for an overview, cf. Nijstad & Stroebe, 2006).[2]

Moderators of Process Gains and Losses

Our exemplary creative team might be unsuccessful. In face-to-face brainstorming, process losses typically outweigh process gains: The actual performance in terms of quantity and quality of ideas of a typical group interacting falls well below its nominal group potential (for an overview, see Mullen, Johnson, & Salas, 1991). So, contrary to popular belief, it is not wise to employ interacting groups instead of individuals for brainstorming to ensure high performance. This result, however, cannot be generalized to other group performance situations. Whether gains outweigh losses or the other way around for a specific group can be influenced by several factors (for a review, see Kerr & Tindale, 2004), including personal attributes like gender and personality of the group members, leadership tools like goal setting, the characteristics of the task at hand, and—as we argue in this article—factors that impair or enhance the individual group members' performance like sleep deprivation or caffeine.

It is important to note that different moderators of group performance are likely to interact with each other. For example, whether and how sleep deprivation affects a group's performance depends on the characteristics of the task this group is working on. Our article is the first to systematically analyze how individual-level impairments and enhancements can affect performance in groups and how this can be studied. In an attempt to find a balance between introducing this new topic in a concise and comprehensible way and doing justice to the complexity of it, we follow an approach we later also recommend to others: we first (i.e., in this section) presume a number of default boundary conditions, prominently a smaller task group (rather than a crowd), a group that is homogeneous (rather than diverse) in being impaired or enhanced, and—most importantly—what we call a "typical group task." These are tasks that are very prominent in the modern-day work context. In such typical group tasks, increases in (a) cognitive capacity, alertness, and motivation and (b) information sharing and collaboration are beneficial for group performance. The second requirement tends to exclude very simple, repetitive, non-cognitive tasks. Although such tasks might be common, they seem less likely to be undertaken in groups and, hence, are less relevant to our analysis. Included in such typical group tasks would be, just to name a few examples, mutual information generation and brainstorming, collective judgment or decision-making tasks, and verbal as well as non-verbal coordination tasks (such as surgery in a team). Our subsequent claims are targeted at such typical group tasks, and we note whenever our analysis requires a more detailed specification of task characteristics. Later in the article, however, we explicitly discuss potential moderators of the effects of individual-level impairments and enhancements in groups. Besides task characteristics, these are group size and diversity in the group's composition.

In what follows, we first describe how the effects of a specific performance impairment (sleep deprivation) and a specific performance enhancement (caffeine) can be changed by acting in a group. We then further illustrate our GIE framework for studying other individual-level performance impairments and enhancements in groups.

How Acting in a Group Can Change the Effects of Sleep Deprivation and Caffeine

In their search for moderators of group performance, researchers have most commonly focused on the effects of characteristics of the group members or of their work environment. So far, surprisingly few have looked at factors known to act as a performance impairment or performance enhancement at the individual level. Sleep deprivation and caffeine are prime examples for such factors. Despite their obvious prevalence and practical relevance, studies investigating how performance is affected by these two factors when it is achieved in groups are still very scarce. Moreover, although there are several powerful frameworks for analyzing group performance (e.g., Hackman & Morris, 1975; Ilgen, Hollenbeck, Johnson, & Jundt, 2005; Larson, 2010; McGrath, 1984), so far no general framework has been proposed specifically on how to best analyze the effects of such individual-level impairments or enhancements on group performance. Our article—and, hence, the GIE framework—aims to fill this gap.

Numerous empirical studies confirm what we know from our own everyday experience: loss of sleep and caffeine intake influence individual cognitive performance. Hence, they influence nominal group performance. We argue, however, that both factors are likely to show additional effects on the group-specific components of group performance. Below, we present a literature-based analysis for sleep deprivation and for caffeine, and examine how they can affect motivation gains and losses, individual capability gains and losses, and coordination losses in groups.

For each factor, we formulate several specific hypotheses. To illustrate our predictions, we introduce a "grouping helps" versus "grouping hurts" terminology. Grouping helps if working together in a group attenuates negative consequences of an impairment the group members show on the individual level or if working together in a group augments positive consequences of an individual-level enhancement. In contrast, grouping hurts if working together in a group augments negative consequences of an individual-level impairment or attenuates positive consequences of an individual-level enhancement. Our analysis not only suggests specific group-level effects of sleep deprivation and caffeine but should also serve as a useful illustration of the GIE framework for investigating the effects on groups any factor that can either impair or enhance individual-level performance can have.

Sleep Deprivation and Performance in Groups

Sleep deprivation: A brief introduction. Although its exact purpose is still unknown, sleep clearly plays a crucial role in human biology. It exerts a restorative effect on the brain and enables the reorganization of neural activity (e.g., Hobson, 2005; Saper, Scammell, & Lu, 2005; Xie et al., 2013; Yang et al., 2014; cf. also Horne, 1988b). Sleep deprivation simply refers to the condition of having had insufficient sleep (i.e., less than 6-10 hr within a 24-hr period for a healthy adult, albeit with large interpersonal variation; Hirshkowitz et al., 2015). Sleep deprivation has several deleterious effects on individual cognition. It has been shown to negatively affect multiple distinct brain processes, particularly by disrupting the integrative functioning of the prefrontal cortex, leading to overall impairments in different cognitive functions (Durmer & Dinges, 2005; Harrison & Horne, 2000). Also on a societal level, sleep deprivation has increasingly been linked to not only losses in productivity (Rosekind et al., 2010) but also work injuries (Barnes & Wagner, 2009), airline (Price & Holley, 1990) and motor vehicle accidents, as well as industrial disasters (Dinges, 1995; Miyata et al., 2010; Philip et al., 2014). The prevalence of sleep deprivation seems to be very high with 28% of U.S.-American survey respondents reporting that they sleep 6 hr or less per night, and an additional 7% indicating that they sleep 7 hr or less (Schoenborn & Adams, 2010).

Sleep deprivation, acute or chronic, can be caused by sleep disorders like insomnia or sleep apnea. But in addition, societal factors associated with our current 24/7 lifestyle—like increasing productivity demands, round-the-clock access to technology, and shifting work schedules—make sleep deprivation likely to occur (Åkerstedt, 1998; Barnes, 2011; Chatzitheochari & Arber, 2009).

Our immediate concern is how sleep deprivation might affect performance when acting in groups. Given how often teams like fire fighters, politicians, power plant employees, or medics work long shifts overnight, it is surprising that only two empirical studies have been published so far that investigate the effects of sleep deprivation on group-specific aspects of performance. Both of these studies focused on potential gains and losses in motivation.

Sleep deprivation and gains and losses in motivation. On the individual level, sleep deprivation has been alleged to make people more prone to loafing; that is, they appear to spend relatively more of their work time engaged in their personal pursuits (Wagner, Barnes, Lim, & Ferris, 2012). Hoeksma-van Orden, Gaillard, and Buunk (1998) compared the performance on three cognitive tasks over a 20-hr period between individuals and four-person groups. All participants worked at the tasks individually, so there was no social interaction in the group condition, although incentives depended on mean-member performance. For all tasks, participants received trial by trial feedback (e.g., correct vs. incorrect), but there was no feedback on total (across trial) individual or group performance. For all three tasks, they found a significant interaction between the individual/group factor and time working: Performance was more adversely affected by lack of sleep (that is, fatigue) in the group condition than in the individual condition. The authors concluded that sleep deprivation made group members exert less effort to contribute to the group's goal ("social loafing"; Latané, Williams, & Harkins, 1979). This suggests that grouping hurts: Sleep deprivation can lead to motivation-related process losses that decrease a group's performance beyond the negative effect sleep deprivation has on the individuals' performance. However, in a follow-up study, Hoeksma-van Orden et al. also showed that these process losses could be reduced by making public the group members' individual contributions to the overall performance.

In a similar vein, Baranski and colleagues' (2007) participants worked at a complex threat assessment task. Within each block of trials, participants sometimes worked individually and sometimes in four-person groups. Group members had access to unique information, which, if poorly evaluated, could degrade their mutual performance. There were 14 trial blocks, extending over 28 hr; independent measurements confirmed that about half way through the study, participants reported becoming increasingly sleepy. During the initial blocks (low sleep deprivation), there were no differences in performance (accuracy and processing time) between individuals and group members. Performance in both conditions degraded as participants became sleepier, but this deterioration was significantly larger in the individual condition than in the group condition—grouping helped. The authors argued that this relatively better group performance was attributable to social compensation: All group members received feedback about one another's performance at the highly interdependent group task. Hence, they were aware of the fatigue-induced decline in their mutual performance and tried to compensate for the low performance of others. This implies that groups that receive information about their individual contributions may, when possible, engage in compensatory effort to attenuate the negative effects of sleep deprivation. Taken together, these two articles suggest that the group-specific motivational aspects of performance are affected by sleep deprivation: Sleep deprived groups may be more prone to social loafing, but if individual performance impairments are salient, performance-restoring—or even enhancing—effects can be evoked. These findings suggest a generally promising technique: Making group members aware of their individual contribution to the group's performance promotes high performance, because the group members might not only actively compensate for their own but also for other group members' cognitive impairments.

Keeping an eye on the group members' motivation in general seems to be good advice, as sleep deprivation is also known to make individuals less empathic and less able to solve conflicts (Gordon & Chen, 2014), as well as less morally aware (Barnes, Guina, & Wagner, 2015). They are more sensitive to what they experience as unfairness and are more guided by their emotions in social decisions (Anderson & Dickinson, 2010). Also, the depletion of resources for self-regulation ("ego depletion"; Baumeister, Bratslavsky, Muraven, & Tice, 1998) has been linked to fatigue (Evans, Boggero, & Segerstrom, 2015; Hagger, Wood, Stiff, & Chatzisarantis, 2010). Sleep deprivation has been shown to induce ego depletion, thereby making individuals prone to unethical behavior (Barnes, Schaubroeck, Huth, & Ghumman, 2011; Christian & Ellis, 2011) and deception (Welsh, Ellis, Christian, & Mai, 2014). This could lead to further motivation losses within a group (cf. Abele & Diehl, 2008). Sleep deprived individuals also tend to perceive neutral stimuli as more negative (Tempesta et al., 2010). Hence, to keep spirits high seems to be of particular importance in sleep deprived groups (cf. also Barnes, 2011; Barnes & Hollenbeck, 2009).

Sleep deprivation and gains and losses in individual capability. For the influence of sleep deprivation on process gains or losses regarding individual capability, no data has been published so far. Nonetheless, we can formulate preliminary hypotheses based on what we know about how sleep deprivation affects individuals. When it comes to potential gains in individual capability due to working together in a group, sleep deprivation is likely to attenuate them: Acute sleep deprivation is clearly shown to impair a range of capability-relevant cognitive functions like attention and working memory (for a review, see Alhola & Polo-Kantola, 2007). Sleep deprived individuals show similar cognitive impairment to patients with prefrontal brain lesions (Killgore, Balkin, & Wesensten, 2006; Killgore, Lipizzi, Kamimori, & Balkin, 2007), older people (Chee & Choo, 2004; Harrison, Horne, & Rothwell, 2000), or people under the influence of alcohol (Falleti, Maruff, Collie, Darby, & McStephen, 2003; Williamson & Feyer, 2000). Basically, sleep deprivation reduces cognitive capacity because extra resources need to be allocated simply to stay awake (Ilkowska & Engle, 2010). For performance in groups, this means that gains in individual capability are less likely under sleep deprivation, as group members have less cognitive resources to pay attention to (verbal or non-verbal) cues passed on by other group members, which in many tasks is necessary for process gains like cognitive stimulation to occur.

Sleep deprivation can not only undermine process gains but it simultaneously increases the probability for losses in individual capability. Sleep deprived individuals tend to think less creatively (Horne, 1988a) and are less able to update information (Harrison & Horne, 2000; Killgore et al., 2006; M. E. Smith, McEvoy, & Gevins, 2002), to form new memories (Chee & Choo, 2004; Yoo, Gujar, Hu, Jolesz, & Walker, 2007) or to switch between different tasks (Couyoumdjian et al., 2010). Hence, under sleep deprivation, group members are presumably more likely to stick to single aspects of the interaction, whether it is a certain category of ideas in brainstorming or a specific suggestion for a solution to a decision problem. Individuals being able to revise their own thoughts and preferences can be crucial for high performance in groups, for example, to avoid cognitive restriction (e.g., Kohn & Smith, 2011) or a suboptimal decision alternative being chosen (e.g., Faulmüller, Kerschreiter, Mojzisch, & Schulz-Hardt, 2010; Greitemeyer & Schulz-Hardt, 2003). Moreover, fatigue seems to reduce epistemic motivation (for a review, see Kruglanski & Webster, 1996). This "willingness to expend effort to achieve a thorough, rich, and accurate understanding of the world" (De Dreu, Nijstad, & van Knippenberg, 2008, p. 23) has been directly linked to group function in De Dreu et al.'s (2008) Motivated Information Processing in Groups model. If epistemic motivation is reduced in a group situation, individual capability–related factors like systematic information search and processing, flexibility of thought, and divergent thinking suffer. In summary, regarding the likely effects of sleep deprivation on individual capability, grouping hurts.

However, being aware of the impairments caused by sleep deprivation could attenuate losses in individual capability. Sleep deprivation does not seem to impair important functions of meta-cognition: Individuals are still able to self-monitor their capabilities and declining performance goes along with declining confidence in own outputs (Baranski, 2007; cf. also Dorrian, Lamond, & Dawson, 2000), or a change in cognitive strategies (Tavakoli, Muller-Gass, & Campbell, 2015). In a similar vein, Hockey's (1997, 2011, 2013) Compensatory Control Model suggests that individuals can maintain their level of performance at a given task, although at the expense of latent decrements like increased physiological activation or fatigue after-effects (cf. Vincent et al., 2015). Hence, sleep deprived group members might try to compensate for their impairments by using resources offered by other group members. In this way, awareness of individual impairments could lead to compensatory efforts and attenuate process losses. For example, because taking others' perspectives seems to enhance creativity in teams (Hoever, van Knippenberg, van Ginkel, & Barkema, 2012), such compensation for sleep deprivation could enhance group member creativity. Such predictions are, however, more speculative than those leading to the conclusion presented above (i.e., that grouping hurts).

Sleep deprivation and losses in coordination. In an investigation on the effects of fatigue on performance in a vigilance task, Frings (2015) found that even though working in a group apparently increased participants' motivation to spot stimuli, sleep deprived groups performed worse than sleep deprived individuals, as measured by the number of absent stimuli wrongly classified as present. The author suggests that this increased number of "false alarms" might have been due to group members distracting each other. This suggests that sleep deprivation can lead to coordination losses. Increased coordination losses can also be expected in more complex cognitive tasks. To effectively interact with other group members, individuals working together need to be able to simultaneously pay attention to information provided by others and keep in mind their own contribution to the group's task. Due to their reduced working memory capacity (Ilkowska & Engle, 2010), sleep deprived group members may also be more likely to forget what they were going to say when exchanging verbal information with other group members during the time someone else is speaking—thereby increasing production blocking. Hence, group members are likely to contribute less of their ideas or knowledge when they are sleep deprived. Regarding the information they do contribute, due to their less creative thinking (Horne, 1988a) and their overall reduced cognitive capacity, sleep deprived group members should be even more likely to "go with the default," leading to an increase in discussion biases. These biases comprise the tendency to mainly discuss such information that is consistent with the group members' personal preferences (e.g., Dennis, 1996; Faulmüller, Mojzisch, Kerschreiter, & Schulz-Hardt, 2012; Mojzisch, Kerschreiter, Faulmüller, Vogelgesang, & Schulz-Hardt, 2014) and such information that is already shared among group members (e.g., Stasser & Titus, 1985; for a review, see Lu, Yuan, & McLeod, 2011). In several types of decision tasks, these biases can be detrimental to high group performance, as they hinder the revision of initial suboptimal decision tendencies in light of new or more complete information (e.g., Stasser & Titus, 1985). Coordination losses can be increased further because sleep deprived individuals are less able to withhold inappropriate responses to stimuli (Anderson & Platten, 2011; Drummond, Paulus, & Tapert, 2006), suggesting that they are more likely to make useless contributions that could slow down the group instead of serving the mutual goal. Moreover, more severe sleep deprivation results in ineffective communication and impaired language comprehension (Harrison & Horne, 2000) which is detrimental for successful group coordination. Hence, grouping hurts.

However, similar to losses in motivation and (to a lesser degree) individual capability, it is possible that a group might be able to compensate for the problematic effects sleep deprivation has on its members. Earlier, we noted that under certain conditions (e.g., high interdependence, member contributions being made public), sleep deprived individuals might work harder when being in a group to compensate for the anticipated or observed suboptimal performance of other group members (i.e., grouping could help). Research on the effects of alcohol on group performance suggests that such compensation may occur not only via increased effort but also via more optimal coordination of member resources. The result pattern in these studies is that the detrimental effect of alcohol on performance was not observed among groups (Abrams et al., 2006; Frings et al., 2008; Hopthrow, de Moura, Meleady, Abrams, & Swift, 2014). Although this could conceivably stem from motivational gains in the tipsy groups (via social compensation), there is direct evidence for relatively better coordination of member contributions in such groups. Specifically, after drinking, groups were more likely to ignore poor or extreme member judgments and to take longer to decide (Abrams et al., 2006; Frings et al., 2008). These findings are consistent with a "group monitoring" (Abrams et al., 2006, p. 628) account that holds that when individual judgment is impaired (e.g., by alcohol), group members change their strategy for collective judgment, becoming more systematic in processing the available member input, which attenuates the extent of impairment in the group. In the same fashion, sleep deprivation could prompt such group monitoring—a hypothesis supported by the finding that working in a group can compensate for individuals' decreased cognitive flexibility in problem solving under sleep deprivation, leading to higher quality problem solving in sleep deprived groups compared with individuals (Frings, 2011). Hence, when group monitoring is possible, that is, when the impairment is not strong and is evident to group members, and when effective coordination strategies are available, coordination losses can be dampened.

Summary and hypotheses. In sum, in typical group tasks, sleep deprivation is likely to negatively affect different group-specific components of performance, thereby inhibiting groups over and above the aversive effects it has on each individual within that group. Sleep deprived groups may be prone to social loafing under certain circumstances, benefit less from each other's knowledge, and exchange and integrate less useful information. Importantly, these impairments come in addition to the individual-specific effects of sleep deprivation. Hence, in contrast to individual performance, group performance is not only threatened by individual-level impairments of group members, but can additionally suffer from negative group-specific losses. In other words, grouping can hurt: When it comes to performance, sleep deprivation potentially hits groups even harder than individuals. However, there is also a clear possibility for sleep deprived groups to compensate for their individual-level impairments (cf. Baranski et al., 2007; Frings, 2011)—a possibility that is not available to individuals without social interaction. This illustrates the danger that lies in trying to simply transfer findings on the effects of sleep deprivation on individual performance to the group level. In this case, the negative effects of sleep deprivation on group performance—but also the possibility for compensation due to social interaction when being offered the right conditions—would have been overlooked.

We formulate the following conceptual hypotheses for typical group tasks[3]:

Hypothesis 1a: Sleep deprivation affects group members' motivation, and this effect is moderated by the identifiability of individual group members' contributions to the group task. When individual contributions are not identifiable, sleep deprivation decreases gains and increases losses in motivation, with negative implications for group performance. In contrast, when individual contributions are identifiable, sleep deprivation increases gains and decreases losses in motivation, with positive implications for group performance.

Hypothesis 1b: Sleep deprivation affects group members' individual capability. It decreases gains and increases losses in individual capability, with negative implications for group performance. More speculatively, this effect can be further moderated by awareness of individual impairment, with positive implications for group performance when awareness is high.

Hypothesis 1c: Sleep deprivation affects group members' coordination, and this effect is moderated by the potential for group monitoring. When the conditions for group monitoring are poor, sleep deprivation increases losses in coordination, with negative implications for group performance. In contrast, when the conditions for group monitoring are good (the group members' impairment due to sleep deprivation is low or medium, awareness of the impairment is high, and effective coordination strategies are available), sleep deprivation decreases losses in coordination, with positive implications for group performance.

Caffeine and Performance in Groups

Caffeine: A brief introduction. Caffeine is a psychoactive substance, chemically belonging to the group of methylxanthines. It acts as a central nervous system stimulant by inhibiting adenosine which slows down neural activity (Ferre, 2008). As a result, it has a general effect of promoting wakefulness and restoring alertness. Caffeine can be found in different natural sources like the coffee plant, the tea bush, and the kola nut and is consumed in a variety of nutritional and pharmaceutical products like coffee, chocolate, or pain medication (Barone & Roberts, 1996). The amount of caffeine contained in these products varies greatly, even within the same category. For example, the average amount of caffeine in a cup of coffee ranges between 19 mg for instant coffee to 177 mg for boiled ground coffee (Nehlig, 1999). There is also a great variation in caffeine consumption between individuals and countries. However, it occurs in almost every society and culture, and both the percentage of people consuming caffeine and the amount consumed are on the rise (Nehlig, 1999). In the United States, for example, it is used daily by 80% of the population, with an average daily dose of 193 mg, the main sources being coffee, soft drinks, and tea (Frary et al., 2005).

Caffeine might sometimes be ingested without the direct aim to do so (e.g., when having a coffee solely for its taste) or even without knowing about it (e.g., when eating chocolate ice cream). However, it is also regularly consumed in a conscious attempt to cope with the challenges of a 24/7 lifestyle to improve wakefulness or alertness throughout the whole workday. Compared with other stimulants with similar effects, caffeine is easily available and fully accepted socially, so it can be consumed with the explicit goal of enhancing performance without fearing stigmatization (cf. Faulmüller, Maslen, & Santoni de Sio, 2013). This is done in different jobs like professional sports (cf. Reyner & Horne, 2013), long distance driving (Sharwood et al., 2013), or in medical professions (Jackson & Moreton, 2013).

Whether caffeine can measure up to users' performance-enhancing expectations has been a long-standing research question. The first systematic study investigating the effects of caffeine on human performance was sponsored by the Coca-Cola Company and published over 100 years ago (Hollingworth, 1912). Since then, thousands of other publications on that topic have followed (for a comprehensive introduction, see Nehlig, 2004). Whereas research on sleep deprivation unambiguously points to adverse effects on many aspects of individual performance, the state of research on the effects of caffeine is less definite and far more controversial. Overall, caffeine seems to more clearly influence low-level functions like perception and motor activity, than high-level functions like cognition, learning, and memory. Also, some effects seem to be moderated by factors like age, habituation, or even personality (for reviews on the effects of caffeine on individual performance, see Einöther & Giesbrecht, 2013; Nehlig, 2010; A. P. Smith, 2002). Hence, contrary to lay theory, "it appears that caffeine cannot be considered a 'pure' cognitive enhancer" (Nehlig, 2010, p. S91).

The question of to what degree caffeine intake can compensate for the adverse effects of sleep deprivation is a complex one and highly debated. Some studies have found, for example, that moderate doses of caffeine can improve vigilance and reaction time in sleep deprived individuals (e.g., Lieberman, Tharion, Shukitt-Hale, Speckman, & Tulley, 2002), whereas others did not find any such performance-enhancing effect (e.g., Killgore et al., 2007). Whether or not caffeine can compensate for performance impairments due to sleep deprivation on the individual level depends on the interaction of several factors like severity of sleep deprivation, caffeine dose, and cognitive functions crucial for performance in the given task. As the state of research is indefinite on the individual level, any analysis trying to draw conclusions for groups would be highly speculative. Hence, in this article, we limit ourselves to separately analyzing the influences of sleep deprivation and caffeine on group performance.

Given the prevalence of its use, many groups regularly perform under the influence of caffeine. Surprisingly, no study has been published yet that investigates the influence of caffeine on the group-specific aspects of performance. Hence, below we review work on caffeine and individual functioning and, using those findings that are more consistent, derive hypotheses for its potential influences on gains and losses in motivation, individual capability, and coordination.

Caffeine and gains and losses in motivation. There is no direct evidence on how caffeine influences motivation. However, mainly using findings on mood-related concepts, we speculate that the intake of caffeine—at least in moderate doses—can positively affect group-specific aspects of performance regarding motivation: In other words, grouping helps. One of the more consistent findings on caffeine is that it can improve mood, for example, by making individuals feel less sad and gloomy, but more happy and cheerful (e.g., Quinlan et al.,

2000) or by making them feel less drowsy and sluggish, but more energetic and alert (e.g., Heatherley, Hayward, Seers, & Rogers, 2005). Also, caffeine in low to medium doses can reduce anxiety (cf. Nehlig, 2010). In the context of athletic performance, one study found that participants who had consumed caffeine perceived exercise to cost less effort than participants who had not (although this perception of reduced effort did not improve athletic performance; Hadjicharalambous et al., 2006). More specific to social situations, in one study, individuals who were given caffeine felt more friendly, more attentive, and more sociable than the control group, and also more keen to work (A. P. Smith, Kendrick, & Maben, 1992). These results suggest that when working together in a group, at least in tasks where sociability promotes performance (e.g., mutual decision making or tasks depending on creativity), individuals who have consumed caffeine might enjoy social interaction more, therefore potentially producing motivational gains by helping their fellow group members, especially when they are on good terms with them rather than being strangers (cf. Kerr & Seok, 2011). Also, motivation losses might be reduced by being more trustful and less prone to social loafing.[4]

Even though research seems to paint an overall positive picture when it comes to the effects of low to medium doses of caffeine on mood and motivation (cf. Casas, Ramos-Quiroga, Prat, & Qureshi, 2004), high doses can lead to anxiety (Green & Suls, 1996; Sicard et al., 1996), nervousness (cf. Nehlig, 2010) and negative mood in general (e.g., Liguori, Hughes, & Grass, 1997). It has been suggested that caffeine might have positive effects on mood in doses up to 300 mg, but negative effects at higher doses (Lieberman, 1992 as reported in B. D. Smith, Osborne, Mann, Jones, & White, 2004). Hence, albeit a little speculatively, we assume an inverted U-shaped relationship between caffeine and group member motivation at typical group tasks, mediated by mood.

Caffeine and gains and losses in individual capability. More specific predictions can be made regarding individual capability, suggesting that grouping helps. Dozens of studies have investigated the effect of caffeine on attention, overall yielding positive results for both simple and more complex tasks (cf. Einöther & Giesbrecht, 2013). For example, as shown in a now classic study, even in a very low dosage (32 mg, which is about the amount that one glass of Coca-Cola® contains) caffeine can improve vigilance and reaction time (Lieberman, Wurtman, Emde, Roberts, & Coviella, 1987). Moreover, caffeine improves performance in tasks that involve working memory (cf. Nehlig, 2010). These findings suggest process gains in individual capability, since group members under the influence of caffeine should be more able to pay attention to what their fellow group members do and to remember what they have learned, promoting greater exploitation of other members' input and strategies. For example, in non-verbal coordination tasks, group members can more easily pick up knowledge or skills from others which they can, in turn, contribute to the group's performance. Also, in typical verbal group tasks, caffeine is likely to have some benefits: It has been shown to improve learning when information is presented passively (cf. Nehlig, 2010)—a situation that is mostly present in information exchanging groups where learning is not an explicit goal but rather a positive side-effect. Recent evidence also suggests that caffeine helps to build long-term memory (Borota et al., 2014). Moreover, another study found that caffeine led to a fast and frugal verbal generation of options for action in decision-making situations (Häusser, Schlemmer, Kaiser, Kalis, & Mojzisch, 2014). It also helps in logically evaluating verbal statements (A. P. Smith, 1994) and in systematic information processing—the latter leading to increased attitude change when being presented with high-quality arguments (Martin, Laing, Martin, & Mitchell, 2005; Mintz & Mills, 1971). Hence, caffeine might enable group members to better process verbal information others in the group bring forward, making process gains like cognitive stimulation more likely in a variety of tasks. For example, as work on brainstorming (e.g., DeRosa, Smith, & Hantula, 2007; Nijstad & Stroebe, 2006) suggests that mutual stimulation may increase creativity, we might expect caffeine to enhance individual creative capability. An interesting, although very speculative question is, given that reduced cognitive capacities due to factors like fatigue or environmental noise (Kruglanski & Webster, 1996) and time pressure (De Dreu, 2003) reduce epistemic motivation, might higher capacities due to caffeine use increase epistemic motivation? If so, working in groups under the influence of caffeine could evoke gains in individual capability by, for example, promoting deeper information processing or more creative thinking (cf. De Dreu et al., 2008).[5]

In turn, losses in individual capability seem to be less likely under the influence of caffeine. Overall, caffeine improves vigilance, concentration, and the ability to focus (cf. Einöther & Giesbrecht, 2013; Nehlig, 1999). Depending on personal characteristics like age (Hogervorst, Riedel, Schmitt, & Jolles, 1998) and personality (Gupta, 1991), people seem to be less sensitive to distractions when they have taken caffeine. This suggests that group members might be less negatively influenced by the interaction process itself.

Similar to the effects of caffeine on mood, an inverted U-shaped effect of caffeine on cognitive performance has been suggested. Some studies (e.g., Hasenfratz & Bättig, 1994; Tieges, Ridderinkhof, Snel, & Kok, 2004) found a higher likelihood for errors in individuals who received very high doses of caffeine. Others (e.g., Brunye, Mahoney, Lieberman, Giles, & Taylor, 2010; Maridakis, Herring, & O'Connor, 2009; Warburton, 1995) showed a simple positive correlation between dose and cognitive performance. However, research overall paints the picture that the effects of caffeine on basic cognitive functions are surprisingly unrelated to dose—at least up to an amount that is typically consumed by habitual caffeine users (up to 400 mg, cf.

Einöther & Giesbrecht, 2013). Hence, contrary to the effects of caffeine on process gains and losses in motivation, we assume no inverted U-shaped relationship between dose of caffeine and individual capability–related process gains and losses.

Caffeine intake and losses in coordination. Caffeine might have the potential to dampen coordination losses—at least for a certain range of caffeine doses. One of the rather uncontroversial findings is that low to moderate doses of caffeine improve reaction time (cf. Einöther & Giesbrecht, 2013). This can lead to a grouping-helps effect by reducing coordination losses that arise from too slow reactions to actions of fellow group members, most prominently in tasks that require fast coordination of physical movements. Importantly, however, the intake of very high doses of caffeine is likely to have the opposite effect: It not only corrupts the positive effect on reaction time (Roache & Griffiths, 1987) but can also lead to jittery movements (cf. Nehlig, 2010; Rogers, Heatherley, Mullings, & Smith, 2013)—which might severely increase process losses in tasks that depend on optimal coordination of hand movements, such as precision engineering, handcraft, sports, or surgery. In this case, grouping could hurt.

It is more difficult to infer from existing research how coordination losses in verbal tasks might be affected. One important source for coordination losses is insufficient knowledge sharing—as thorough information exchange can be crucial for high-quality group decisions (e.g., Stasser & Titus, 1985). Some work tentatively suggests that group members might at least be willing to share more information when they have consumed caffeine: Caffeine induces its well-known wakefulness effect by increasing physical arousal (e.g., Huang et al., 2005). Arousal from different sources has been demonstrated to increase people's intention to share information (Berger, 2011). However, this causal chain is very speculative and lacks a sufficient empirical foundation. Thus, we refrain from formulating a clear-cut hypothesis regarding coordination-related process losses in verbal tasks.

Summary and hypotheses. In sum, we conclude that caffeine, partially depending on dose, can affect groups both more positively and negatively than individuals. Via its mood-improving effect, caffeine in low to medium doses can promote motivation gains and attenuate motivation losses, thereby resulting in a particularly positive effect in groups. High doses, on the contrary, might have the opposite effect by evoking anxiety in individuals. By increasing attention and the ability to systematically process verbal information, caffeine can increase gains in individual capability and at the same time decrease losses by making individuals less vulnerable to distractions. Hence, when it comes to individual capability, grouping might help: Groups benefit more from caffeine than individuals do. The amount of caffeine ingested is of great importance with respect to coordination losses. By decreasing reaction time, low to medium doses of caffeine might help to prevent coordination losses in some physical tasks, whereas high doses should affect groups that depend on physical precision even more adversely than individuals by leading to jittery movements. No clear prediction can be made as to whether caffeine influences coordination in verbal tasks. As in the case of sleep deprivation, the effects of caffeine on the group-specific components of group performance come in addition to its effects on the individual-specific components. Again, we cannot simply transfer the findings from individual performance to group performance.

We formulate the following conceptual hypotheses for typical group tasks[6]:

Hypothesis 2a: Caffeine affects group members' motivation, and this effect is moderated by caffeine dose and mediated by mood. When the dose is low or medium, caffeine leads to positive mood and, as a result, increases gains and decreases losses in motivation, with positive implications for group performance. In contrast, when the dose is high, caffeine leads to negative mood and, as a result, decreases gains and increases losses in motivation, with negative implications for group performance.

Hypothesis 2b: Caffeine affects the individual group members' capability. It increases process gains and decreases process losses in individual capability, with positive implications for group performance. (This effect is far less likely to be moderated by caffeine dose.)

Hypothesis 2c: In physical tasks, caffeine affects group members' coordination, and this effect is moderated by caffeine dose. When the dose is low or medium, caffeine decreases losses in coordination, with positive implications for group performance. In contrast, when the dose is high, caffeine increases losses in coordination, with negative implications for group performance. (For verbal tasks, no hypothesis can yet be formulated.)

The GIE Framework for Analyzing How Acting in a Group Can Change the Effects of Performance Impairments and Enhancements

In this article, we offer a conceptual analysis of how sleep deprivation and caffeine can influence performance in groups. However, our aim is not only to better understand potential effects of these two factors at the group level but also to suggest that the same framework could be useful for studying how acting in a group changes the effects of other individual-level impairments and enhancements. Below, we address crucial issues upon which the utility of our GIE framework hinges. First, we consider whether findings on one impairment or enhancement can be generalized to another. Second, by discussing task characteristics, group size and diversity in group composition, we explore how the effects of various impairments and enhancements in groups are likely to be moderated. Third, we give more practical guidelines by illustrating how to use the GIE framework in empirical research practice.

Generalizing Findings From One Impairment or Enhancement to Another

Throughout our discussion of sleep deprivation and caffeine, we have stressed that we cannot directly generalize findings on how an impairment or enhancement affects individual performance to performance in groups. But what about generalizing from one impairment or enhancement to another? Imagine, for example, that one (a) knew precisely which effects a certain enhancement X has on the individual level and also (b) had determined which process gains and losses result at the group level. Suppose further that enhancement Y is known to have very similar effects on the individual level as enhancement X has. Can one, then, assume that Y should produce the same pattern of process gains and losses on the group level as X does? We argue that one cannot. This principle of *non-generalizability* is central for understanding how to think about individual-level impairments and enhancements in groups and the GIE framework. To illustrate this, below we (a) compare sleep deprivation to another prominent individual-level impairment, namely, *stress*, and (b) compare caffeine to another prominent individual-level enhancement, namely, *pharmacological cognitive enhancement*.

Impairments: Generalizing from sleep deprivation to stress. Another common consequence of our 24/7 lifestyle and our deadline-driven work environments is *stress*. Stress is an adaptive reaction to threats in the environment by a complex interplay of psychological, neurophysiological, behavioral, and also social variables (Lazarus, 1974; Selye, 1936). Similar to sleep deprivation, stress can be seen as an individual-level impairment of performance. It has negative effects on diverse cognitive functions, including memory (for a review, see Wolf, 2009) and decision making (for a review, see Starcke & Brand, 2012). Stress is qualitatively comparable with sleep deprivation regarding its effects on individuals' performance. Hence, we might be tempted to assume that—at least under the conditions that are least optimal for sleep deprived groups—grouping would also hurt in the case of stress. However, we cannot simply generalize the group-level effects we might find for sleep deprivation to those likely to occur for stress.

The reason for this non-generalizability is that working in a group can have a major impact on stress at the individual level. Considerable research has found that belonging to a group when facing threat buffers stress (for an overview, see Haslam, 2004). Using a social identity approach (e.g., Haslam, Jetten, Postmes, & Haslam, 2009), this has been attributed to the consequences of knowing that other in-group members are acting in one's collective self-interest (Turner, Oakes, Haslam, & McGarty, 1994). Häusser, Kattenstroth, van Dick, and Mojzisch (2012) found that the mere presence of others with whom one shares a social identity has a strong stress-buffering effect in threatening situations. In this study, group members were not allowed to interact with each other, so stress was reduced solely by the feeling of "we are going through this together." In many work groups, due to a mutual history, shared goals, and high importance of the group or the organization for group members' self-esteem, a shared social identity is established, which acts as a stress buffer (Haslam, Jetten, & Waghorn, 2009; Haslam, O'Brien, Jetten, Vormedal, & Penna, 2005). In addition to the positive effects of the mere presence of other in-group members, groups can provide more tangible support to help deal with stress. Social support has been suggested as a very powerful resource for coping with stress (Cohen & McKay, 1984), and numerous empirical studies have found that it indeed attenuates psychophysiological stress reactions (e.g., Ditzen et al., 2008; Frisch, Häusser, van Dick, & Mojzisch, 2014; Heinrichs, Baumgartner, Kirschbaum, & Ehlert, 2003; Kirschbaum, Klauer, Filipp, & Hellhammer, 1995). Thus, ceteris paribus, groups are relatively less likely to experience stress as a result of a particular task-related threat than individuals are. Hence, when stress is expected to occur during a task, grouping should help to reduce individual stress responses. In other words, the magnitude of this impairment is likely to be attenuated by working in a group (provided group identification and mutual social support are high). This example nicely illustrates the non-generalizability of group-level effects from one impairment (sleep deprivation) to another (stress). Although it might be argued that grouping could also help to cope with fatigue, no strong theoretical or empirical basis for this suggestion exists. Whereas the question for sleep deprivation is whether grouping helps or hurts in coping with the impairment, in the case of stress, grouping can influence the magnitude of the individual-level impairment itself.

The notion that grouping helps when stress is to be expected, however, has one important qualification to it: Even though stress is less likely in groups, if it does manage to occur at comparable levels in both individuals and groups (e.g., because members do not identify with their group or the group offers no social support), such stress is likely to be more harmful in groups than among individuals, due to its negative effects on performance-relevant social processes. This argument is based on research showing that stress impairs abilities required for effective communication and cooperation (for a review, see Frisch, Häusser, & Mojzisch, 2015). For example, stress impairs identifying others' emotions (Smeets, Dziobek, & Wolf, 2009; Tomova, von Dawans, Heinrichs, Silani, & Lamm, 2014), anticipating decisions of others and adjusting one's own decisions accordingly (Leder, Häusser, & Mojzisch, 2013, 2015), as well as remembering social information (e.g., attributes of others; Merz, Wolf, & Hennig, 2010; Takahashi et al., 2004). Such negative effects of stress on social processes would impair group performance over and above the individual performance deficits due to reduced cognitive functioning.

In sum, we would expect that grouping helps to reduce stress and avoid individual-level impairments in the first place, but when group-based stress reduction is absent, grouping hurts: Stress is more detrimental to group performance than to individual performance. Importantly, the factors that govern when grouping helps versus hurts are most likely different for stress (e.g., strength of identification with the group; level of social support in the group) than for other impairments like sleep deprivation.

Enhancements: Generalizing from caffeine to pharmacological cognitive enhancement. Also as a result of our 24/7 lifestyle and increased performance demands, society has seen a rise in the use of what has been termed *pharmacological cognitive enhancement* (PCE), that is "pharmacological interventions that are intended to improve certain mental functions and that go beyond currently accepted medical indications" (Schermer, Bolt, De Jongh, & Olivier, 2009, p. 77). Some healthy people take psychostimulants (intended as treatment for attention deficit hyperactivity disorder) like methylphenidate (e.g., Ritalin®) and mixed amphetamine salts (e.g., Adderall®) or wakefulness-promoting agents (intended as treatment for narcolepsy) like modafinil (e.g., Provigil®) with the aim of improving their cognitive performance. Prevalence studies and informal polls suggest that such PCEs are used by students (e.g., Singh, Bard, & Jackson, 2014), by scientists (Maher, 2008), and by professionals in high-responsibility jobs such as physicians, airline pilots, and military personnel (e.g., Franke et al., 2013; also cf. Greely et al., 2008; Sahakian et al., 2015; Santoni de Sio, Faulmüller, & Vincent, 2014; M. E. Smith & Farah, 2011).

Similar to caffeine, PCEs can indeed positively influence individual cognitive functioning, even for those who don't suffer from any illness (for reviews, see Battleday & Brem, 2015; Ilieva, Hook, & Farah, 2015; Repantis, Schlattmann, Laisney, & Heuser, 2010). However, the effects for currently available substances are not large, they depend on a variety of moderators, and improvements beyond a certain local optimum seem not possible (cf. Husain & Mehta, 2011). PCEs can also influence group-specific aspects of performance. Unlike caffeine, though, there is evidence for a direct influence of PCEs on individual motivation; one study found that psychostimulants increased the willingness of healthy individuals to exert effort in a decision-making task (Wardle, Treadway, Mayo, Zald, & de Wit, 2011). This implies that in groups, such PCEs could increase motivation gains like social compensation and reduce motivation losses like social loafing even in cases where identifiability of individual contributions is low. Similarly—and in this case analogously to our reasoning on caffeine—the effects PCEs have on individual cognition suggest that grouping could also help via process gains and losses in individual capability, and via process losses in coordination. For example, modafinil can improve reaction time, alertness, and some types of working memory in (already well-rested) individuals (Müller, Steffenhagen, Regenthal, & Bublak, 2004; Turner et al., 2003). Similarly, methylphenidate can enhance working memory and planning (Elliott et al., 1997; Mehta et al., 2000). These findings suggest increased gains in individual capability, for example, because their increased memory allows group members to better learn the other members' input. On the contrary, process losses in individual capability are less likely, for example, because the group members' enhanced alertness should make them less sensitive to distractions. Similarly, coordination losses should be reduced, for example, because the positive effects PCEs have on reaction time improve fast coordination of movements (at least for physical tasks). Hence, we might conclude that, for PCEs, similar to caffeine, grouping helps with regard to motivation, individual capability, and coordination.

However, there is a crucial difference between PCEs and caffeine that becomes relevant at the group level. Despite prevalent off-label use, investigations among the general public have demonstrated strong negative views of PCEs (for a review, see Schelle, Faulmüller, Caviola, & Hewstone, 2014). Although many of the general public's concerns mirror those raised in the academic debate on such substances (for overviews, see Bostrom & Sandberg, 2009; Maslen, Faulmüller, & Savulescu, 2014), lay judgments might be tilted in different ways (Caviola, Mannino, Savulescu, & Faulmüller, 2014). PCEs are suspected to be more effective than they actually are (Ilieva, Boland, & Farah, 2013), and judged as a morally unacceptable way to easily succeed. Concerns about unfairness loom particularly large in this context (e.g., Faber, Savulescu, & Douglas, 2015; Santoni de Sio, Faber, Savulescu, & Vincent, in press). In this "social" sense, PCE is fundamentally different from caffeine—independent of these substances' actual pharmacological effects. We suggest that in groups where not all members take PCE (and where use is not concealed), the negative views on these substances could lead to substantial process losses in motivation. Non-users in the group would be likely to overestimate the efficiency of these "smart pills" and become more prone to free riding and experience higher subjective dispensability. Moreover, because the non-users might see their fellow "drug taker" group members negatively and even want to avoid them (cf. Faulmüller et al., 2013), motivation gains like social compensation are far less likely.[7]

In sum, the hypothesis that PCEs, similar to caffeine, increase performance in groups over and above their effects on individuals presupposes that none of the group members hold the prevalent negative opinion on PCEs. Although views on PCEs, as on other performance enhancements, are subject to societal change (cf. Maslen, Santoni de Sio, & Faber, 2015), at present this is unlikely. If group members hold negative views, however, we could expect very different findings than would arise for caffeine, due to motivational reasons. Given the current strong negative view of PCEs in the general public, motivation losses should outweigh other process gains, leading to an overall grouping-hurts effect.

The examples of stress and PCEs illustrate a key aspect of the GIE framework: We cannot generalize findings from one impairment or enhancement to another. One individual-level impairment might not be strongly affected by working in a group (sleep deprivation), whereas another might be attenuated by social interaction (stress). One individual-level enhancement might improve a group's performance over and above performance of individuals (caffeine), whereas another under certain conditions might even act as an impairment for group performance (PCEs). It would go beyond the scope of this article to address all other individual-level performance impairments and enhancements that are worth empirical study in groups (e.g., diet, hunger, naps, physical exercise or inactivity). However, it stands to reason that their net effects in groups will vary considerably, and that comparisons—as, for example, are often drawn between sleep deprivation and alcohol intake—should be avoided on the group level. What is needed is for each to be carefully and specifically analyzed in light of what we know about their effects at the individual level and likely impact on group-specific aspects of performance (as we have attempted here with sleep deprivation and caffeine), to be followed by programmatic empirical research.

Potential Moderators

The effects individual-level impairments and enhancements have on performance are probably not uniform across all groups but are likely to vary with other characteristics. To illustrate such moderation effects, we focus on three particularly important aspects, namely, task characteristics, group size, and group diversity.

Task characteristics. In our above analysis, we have focused on what we have called "typical group tasks," as an amorphous—although very large—set of tasks. However, we want to (re-)emphasize that the specific demands of the task surely is one of the most crucial moderators of the effects of grouping (Hackman, 1968, 1969; Steiner, 1972). Skills, experience, knowledge, individual motives, or interaction patterns that might be beneficial for high performance in one task might be irrelevant or even detrimental in another. For example, whereas exchanging information in a decision-making group critically depends on working memory, crushing as many rocks as possible in an hour does not. Or whereas an attempt to present oneself in the best possible light to other group members can increase contributions in a task where group members feel competent, it can decrease them in a task where group members feel insecure (cf. Faber, Savulescu, & Van Lange, in press).

Task characteristics might also moderate the effects of performance impairments or enhancements in individuals and groups. Ideally, future theory and research will be able to specify these task characteristics. However, we do not believe that any of the extant task taxonomies (e.g., Hackman & Morris, 1975; Laughlin & Ellis, 1986; McGrath, 1984; Shaw, 1963; Steiner, 1972), while very useful for other purposes (cf. Kerr, 2009), yet provide a satisfactory basis for such a specification.[8] Hence, rather than directly try to determine task characteristics as general moderators of the effects of an impairment or enhancements in group performance, we suggest it is at present more fruitful to specify how each particular impairment or enhancement influences performance-relevant variables and then, as a second step, link these variables to specific task characteristics. For example, whether a task depends on face-to-face or virtual communication between group members is generally considered a powerful influence factor in group performance (for a review, see Martins, Gilson, & Maynard, 2004). However, how do means of communication moderate the influence sleep deprivation exerts when working in a group? We have argued that the effects of sleep deprivation depend on whether or not the individual group members' contributions to the joint task are identifiable. This identifiability, in turn, can depend on the group's communication: Identifiability might be higher in a face-to-face situation, where group members can directly observe each other, suggesting greater motivation gains in sleep deprived groups who interact face-to-face. It might just as well be, however, that identifiability is higher in a virtual situation where contributions are recorded (e.g., in an email exchange), suggesting greater motivation gains in sleep deprived groups who interact virtually. Hence, how the task characteristic of virtuality moderates the influence of sleep deprivation on group performance cannot be simply determined, but only via the performance-relevant variables that are influenced by the impairment—in this case, identifiability of individual contributions. In sum, while we are convinced that task characteristics are a crucial moderator for grouping in general and can be one for the effects of grouping on individual-level impairments and enhancements in particular, an analysis of such moderation requires case-by-case consideration of the underlying performance-relevant variables.

It is worthwhile noting that the characteristics of the task are also relevant from a methodological perspective. For complex group tasks, it can be difficult to specify the nominal group potential as a performance baseline, for example, for surgery performed by a health care team or for an interdependent intellectual puzzle. Nevertheless, it is possible in principle to specify such a baseline, and we want again to caution against trying to draw strong conclusions without one. Comparing individual performance with and without an impairment or enhancement provides us with an estimate of this impairment's or enhancement's effect on individual performance. However, it would be misleading to directly compare that effect to an effect we observe in groups with and without the same impairment or enhancement. The reason is that the simple act of accumulating group member resources will have its own effect—above and beyond any distinctive effect of the impairment or enhancement on group processes. Imagine 60% of well-rested individuals can solve some intellectual, Eureka type puzzle (cf. Steiner, 1972), whereas only 40% of sleep deprived individuals can—an effect of 20%. Now imagine that 97% of well-rested four-person groups solve this same puzzle, and 82% of sleep deprived four-person groups do—an effect of 15%. Does this mean that sleep deprivation impairs groups less than individuals in this task? It does not. We would need to first calculate the probability for a well-rested and for a sleep deprived hypothetical four-person group to solve this puzzle based on the success rates for individuals, in other words, the nominal group potential. In such a Eureka task, if at least one group member knows the correct solution, the group can solve the puzzle. Using this "truth wins" model (Lorge & Solomon, 1955), we would expect well-rested four-person groups to solve in 97% of all cases, and sleep deprived groups in 87%. Hence, while the well-rested groups perform at their potential (97% vs. 97%), the sleep deprived groups underperform (82% vs. 87%). So sleep deprivation would actually have additional detrimental effects in groups compared with individuals. This conclusion could not be reached unless we employed nominal group performance as a meaningful baseline. Indeed, some task characteristics might make it hard to estimate the nominal group potential, but it is nevertheless essential to do so.

Taken together, even though we need to be aware that task characteristics potentially moderate the effects of grouping on individual-level impairments and enhancements, we believe that that it will be best to initially focus on tasks that allow for both a clear isolation of the performance-relevant variables and a clear determination of the nominal group potential as a baseline—at least while research on this topic is still in its infancy.

Group size. For both theoretical and pragmatic reasons, we recommend first focusing on relatively small groups when thinking about performance impairments and enhancements in groups. However, group size is another potential moderator to be aware of.

For sleep deprivation, we have argued that under many conditions, it impairs group performance over and above individual performance. Such grouping-hurts effects could be even more pronounced in large groups. Supported by research on comparatively small groups (four members; see Baranski et al., 2007; Hoeksma-van Orden et al., 1998), we have predicted that sleep deprivation decreases gains and increases losses in motivation, provided the individual group members' contributions to the mutual task are not identifiable. Such non-identifiability is more likely in large, compared with smaller, groups. In general, in larger groups, beneficial control mechanisms get lost and more deindividuation and selfish behavior can be observed (Latané, 1981; Postmes & Spears, 1998). This implies that grouping should hurt more in larger sleep deprived groups. Moreover, under sleep deprivation, individuals have reduced cognitive capacities, for example, to focus their attention (Alhola & Polo-Kantola, 2007). Hence, they are more likely to get distracted by the social interaction within the group. A large group offers more possibilities for such distractions, leaving less room for gains and increasing the likelihood of losses in individual capability. With regard to coordination losses under sleep deprivation, large groups are more likely to be adversely affected than smaller groups. For example, in cognitive tasks, the sleep deprived individuals' decreased working memory capacity (Ilkowska & Engle, 2010) makes it harder for them to simultaneously pay attention to information provided by their fellow group members and to make their own potential contributions. The more fellow group members there are, the more likely such coordination losses happen. In sum, sleep deprivation is likely to hit larger groups harder than smaller ones.

For caffeine, the likely effect of varying group size is less straightforward. For example, we have predicted that via increased mood, the intake of low to moderate doses of caffeine reduces motivation losses. Such motivation losses tend to be larger in larger groups (Kerr & Bruun, 1983; Ringelmann, 1913), for various reasons (e.g., reduced identifiability of member contributions in larger groups; more opportunities to free ride for certain tasks). Hence, if the attenuating effect of caffeine on motivation loss were large enough (i.e., more than strong enough to eliminate a small motivation loss in a small group), the net effect could benefit larger groups more than smaller ones. With regard to individual capability, we have predicted that due to their enhanced mental capacities, group members who have taken caffeine can benefit more from their fellow group members' input to the task. Whenever such potential input is greater in larger than in smaller groups, there should be greater possibilities for capability gains. Similarly, when group members have taken caffeine, they should be less negatively affected by the interaction process itself. Such capability losses are more likely in large groups, so here, caffeine could play a larger enhancing role. Similarly, our hypothesized effect of low to moderate doses of caffeine in reducing coordination losses in physical tasks should gain more weight when there is greater potential for such losses—that is, in larger groups. In sum, although a variety of processes change in larger groups, "generally for the worse" (Levine & Moreland, 1990, p. 593), for a reasonably wide range of group tasks, the intake of (low to moderate doses of) caffeine seems likely to enhance the performance of larger groups more than the performance of smaller groups.

Diversity in group composition. There are two principal types of diversity in group research (Larson, 2010): surface diversity (e.g., demographic heterogeneity) and deep diversity (e.g., heterogeneity in knowledge, perspective, or problem-solving strategies). Generally, reviews of the literature in this area (e.g., Hülsheger, Anderson, & Salgado, 2009; Mannix &

Neale, 2005; van Knippenberg & Schippers, 2007) have found little consistent evidence for substantial effects of either type of diversity on group performance. However, there is another type of diversity that is likely to be very important for our current focus—how diverse is the exposure of group members to a particular individual-level impairment or enhancement? In real-world groups, probably both extremes of this kind of diversity are common: homogeneous groups (with, for example, all group members arriving sleep deprived at a very early morning meeting or all group members drinking the coffee provided at the office) and diverse groups (with, for example, levels of sleep deprivation and caffeine consumption varying widely across group members). In our prior discussions on sleep deprivation and caffeine, we deliberately restricted ourselves to groups that are essentially homogeneous in their degree of sleep deprivation or caffeine ingestion, because we believe that it is—both theoretically and empirically—appropriate to begin with the simpler case of homogeneous groups before tackling the considerably more complex case of heterogeneous groups. It is beyond the scope of this article to thoroughly explore those complications, but we do want to acknowledge their importance and briefly touch on a couple of them.

For the case of impairments, consider a group whose members are homogeneously sleep deprived. As described above, we hypothesize that in this case, when the contributions of individual members are identifiable, motivation gains occur because group members try to compensate for the impairment of others. Now imagine a group where only some members are sleep deprived, and individual contributions are identifiable. In that case, at least when the non-sleep deprived members attribute the others' impairments to an intentional or avoidable cause (e.g., like staying up late partying) it is possible that the well-rested members would not be as willing to compensate for the sleep deprivation of others. We tend to be reluctant to exert costly effort for others who could, but are not, performing to their potential (Jackson & LePine, 2003; Kerr, 1983). In extreme cases, the non-sleep deprived group members might even want to alter the composition of the group by making the diminished capacity of their fellows apparent. (For further discussion of attributions in decision-making teams that are heterogeneous in sleep deprivation, see Barnes & Hollenbeck, 2009.)

For the case of enhancements, consider a group where some individuals have not consumed caffeine. These individuals might expect that their fellow group members' caffeine consumption has enhanced their performance and, as a result, be more prone to try to free ride on these members' performance. However, such free riding would depend on the non-caffeine-consumers' individual contributions not being identifiable (cf. Harkins & Petty, 1982; Hoeksma-van Orden et al., 1998), and also be more likely in group tasks where the efforts of one or a few capable members can insure successful group performance (e.g., in Eureka tasks, cf. Steiner, 1972). For such tasks, we expect group members to more willingly free ride on the efforts of those more capable members (Kerr, 1983; Kerr & Bruun, 1983). Such diversity effects, although possible for caffeine, can more confidently be expected for other enhancements, for example, PCEs (as we argued above). In the latter case, diversity could even turn a factor that overall acts as an enhancer in a homogeneous group to an overall-impairment in a diverse group. These examples not only show that diversity can act as a crucial moderator of how individual-level impairments or enhancements affect group performance but also re-illustrate the non-generalizability of findings from one impairment or enhancement to another.

The GIE Framework in Empirical Research Practice

We envision the GIE framework inspiring not only thinking but also empirical research. To help facilitate this, in the following we offer a more concrete guide on how to conduct such research. First, we describe how empirical data should be interpreted to clearly answer the question of how the individual-level impairment or enhancement of interest affects performance when individuals act in groups. Then we present some brief practical research strategies that can help make such (admittedly rather laborious) research more feasible.

Interpreting interaction patterns: Does grouping hurt or help? In what follows, we employ a statistical perspective and discuss how to interpret the data that an empirical investigation of an impairment or an enhancement in groups might yield. When carrying out such research and employing the nominal group potential as baseline, the hypotheses formulated will in essence be interaction hypotheses between the two variables "nominal versus actual group performance" and "impairment/enhancement absent versus present" (cf. Notes 3 and 6 below for examples of such interaction hypotheses). As a result of such a hypothesis, a variety of interaction patterns are possible. How can such patterns be interpreted to discover whether grouping hurts or helps for the impairment or enhancement of interest?

To answer this question, six means are relevant. Figure 1 shows illustrative examples of prototypical interaction patterns of these means and whether they indicate a grouping-helps or grouping-hurts pattern.[9] The first two means are the level of individuals' performance when the impairment or enhancement is absent and the corresponding mean for individual performance with the impairment or enhancement present. Further needed are the corresponding performance levels for nominal groups (i.e., the group potential) without the impairment or enhancement and with the impairment or enhancement. These can be estimated from the individual performance data and should preserve the same ordering.[10] The last two means are the empirically observed performance of actual groups without and with the impairment or enhancement. Figure 1 contains examples where unimpaired or unenhanced groups perform

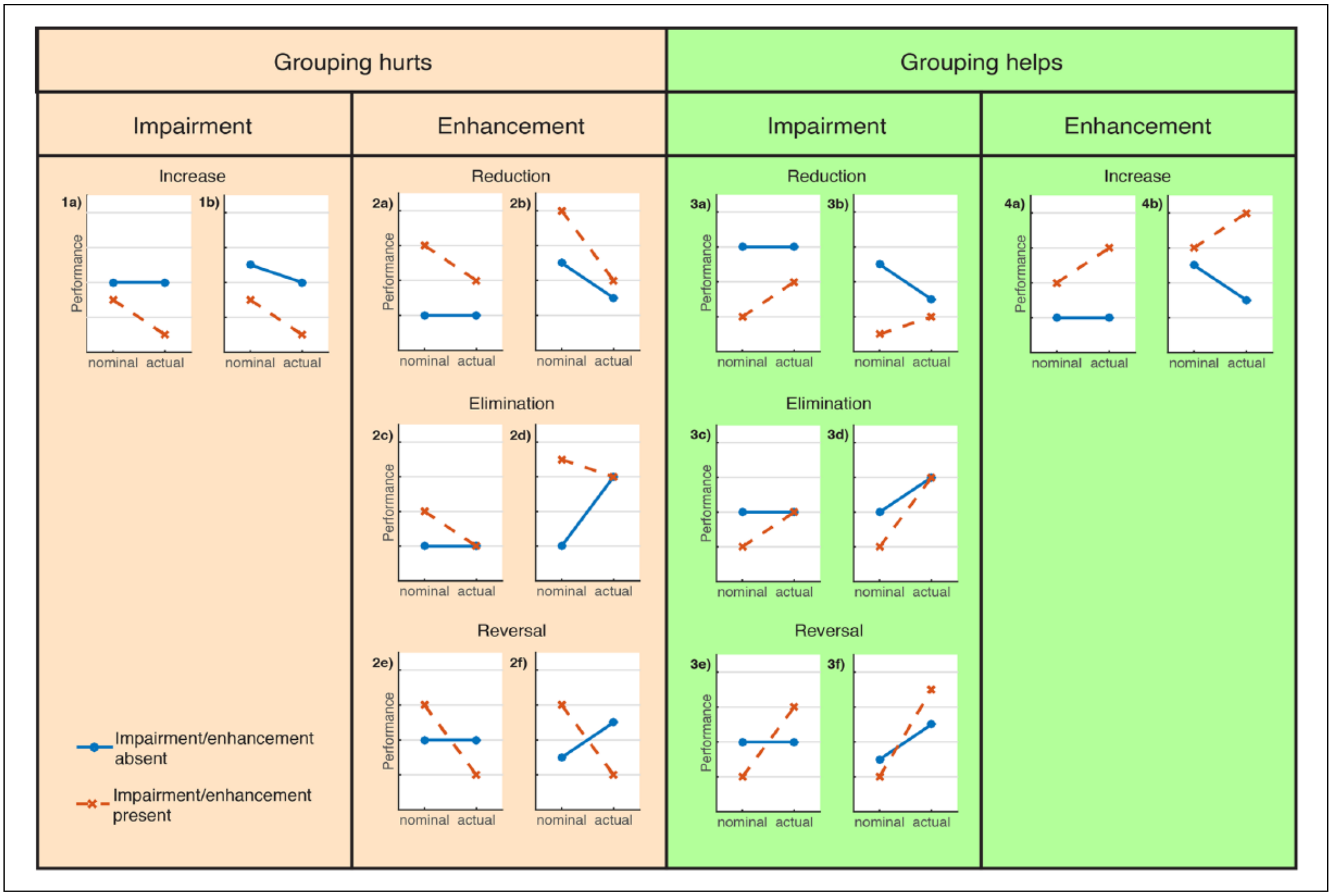

Figure 1. Examples for interaction patterns between the variables "nominal versus actual group performance" and "impairment/enhancement absent versus present."

at their potential (Plots 1a, 2a, 2c, 2e, 3a, 3c, 3e, 4a), below their potential (Plots 1b, 2b, 3b, 4b), and above their potential (Plots 2d, 2f, 3d, 3f).

Grouping hurts performance if working together in a group exacerbates an individual-level impairment and, consequently, a nominal group-level impairment (see first column of Figure 1), or if it attenuates an individual-level (and nominal group level) enhancement (second column). Such grouping-hurts interactions can take many forms, depending on several factors, including the magnitude of the impairment or enhancement, the magnitude of the process gains or losses induced by the impairment or enhancement, and the relative level of unimpaired or unenhanced actual group performance and group potential. Importantly, when grouping hurts in the case of an impairment, the magnitude of the impairment in nominal groups can only be increased (see Plots 1a and 1b for two examples of such effects). However, when grouping hurts an enhancement effect, the magnitude of the enhancement in nominal groups can remain but be reduced (Plots 2a, 2b), can be completely eliminated (Plots 2c, 2d), or can even be reversed (Plots 2e, 2f) in actual groups. While the plots (i.e., 1a-4b) are not exhaustive, the pattern categories (i.e., increase, reduction, elimination, reversal) are. (We give two plots as illustrative examples for each category.) Hence, as Figure 1 illustrates, there are overall fewer possible categories and, hence, interaction patterns when grouping hurts impairments than when grouping hurts enhancements.

Grouping helps performance if working together in a group attenuates an impairment the group members show on the individual-level and, hence, the nominal group-level (see third column of Figure 1), or if it augments an individual-level (and nominal group-level) enhancement (fourth column). The examples illustrate that when grouping helps, the effects of an impairment in nominal groups can be reduced (see Plots 3a and 3b for two examples), eliminated (Plots 3c, 3d) or reversed (Plots 3e, 3f) in actual groups. When grouping helps, however, the effects on an enhancement can only be increased (Plots 4a, 4b). A mathematical presentation of the six relevant means and how to interpret their relation can be found in Table 1.

A note on research strategies. It is evident that group research is generally rather difficult and requires a lot of resources (Kerr & Tindale, 2014). Combining this with another area of research that is difficult and costly (such as experimentally

Table 1. Relevant Means for Analyzing Individual-Level Impairments or Enhancements in Groups and How to Interpret Their Mathematical Relation.

The six relevant means		
Abbreviation	Meaning	How to determine
$Per[I]_{absent}$	Individual performance with impairment/enhancement absent	Observe empirically
$Per[I]_{present}$	Individual performance with impairment/enhancement present	Observe empirically
$Per[NG]_{absent}$	Nominal group performance with impairment/enhancement absent	Estimate from $Per[I]_{absent}$
$Per[NG]_{present}$	Nominal group performance with impairment/enhancement present	Estimate from $Per[I]_{present}$
$Per[AG]_{absent}$	Actual group performance with impairment/enhancement absent	Observe empirically
$Per[AG]_{present}$	Actual group performance with impairment/enhancement present	Observe empirically

Observable mathematical relations of these means	
Relation	Interpretation
$Per[I]_{absent} > Per[I]_{present}$	Impairment. $Per[NG]_{absent} > Per[NG]_{present}$
$Per[I]_{absent} < Per[I]_{present}$	Enhancement. $Per[NG]_{absent} < Per[NG]_{present}$
$Per[NG]_{absent} - Per[NG]_{present} < Per[AG]_{absent} - Per[AG]_{present}$	Grouping hurts in case of an impairment
$Per[NG]_{absent} - Per[NG]_{present} > Per[AG]_{absent} - Per[AG]_{present}$	Grouping helps in case of an impairment
$Per[NG]_{present} - Per[NG]_{absent} > Per[AG]_{present} - Per[AG]_{absent}$	Grouping hurts in case of an enhancement
$Per[NG]_{present} - Per[NG]_{absent} < Per[AG]_{present} - Per[AG]_{absent}$	Grouping helps in case of an enhancement

manipulated sleep deprivation or a pharmacological intervention) may be out of sync with the zeitgeist of conducting and publishing studies at high frequencies. We understand that (particularly young) researchers might be afraid to fall behind in the “publication game” when entering into such an effortful endeavor. However, we wish to encourage such research—not just as an attempt to reduce cognitive dissonance arising from our own career-damaging behavior but rather because of its high theoretical relevance and public interest.

It goes beyond the scope of this article to comprehensively discuss research strategies that can help reduce the effort of adding a grouping manipulation to research on individual-level impairments and enhancements. However, we would like to note that there are some sensible measures one can take. First, we would recommend that any research program should begin with simpler cases, moving onto more complex questions only after robust and reliable findings can be demonstrated for those simple cases. This reasoning underlay our focus when formulating our hypotheses on sleep deprivation and caffeine—a focus on groups that are homogeneous in level of sleep deprivation or caffeine intake, on what we termed *typical group tasks*, and on relatively smaller groups. Second, to reduce effort in data collection, it is possible to employ not only well-controlled experiments but study designs that make use of natural variations in exposure to the impairment or enhancement of interest (i.e., quasi-experiments or correlational field studies; for an example with caffeine, see Streufert et al., 1997). In some cases, within-participants manipulations are also possible (cf. Baranski et al., 2007; Hoeksma-van Orden et al., 1998). Third, depending on which form of data collection is chosen as the most suitable, at the stage of data analysis techniques could be considered that have recently gained popularity for studying groups, for example multilevel modeling (Kenny, Mannetti, Pierro, Livi, & Kashy, 2002; Nezlek, 2008) or social network analyses (Wölfer, Faber, & Hewstone, 2015). Using such techniques, a lot of information can be gained from relatively few data points, especially when naturally existing group structures are investigated.

The GIE Framework at a Glance

Throughout this article, we have illustrated the GIE framework for analyzing how acting in a group can change the effects of individual-level performance impairments and enhancements. To make its key propositions very explicit, here they are summed up:

- We cannot assume that the effects of a particular impairment or enhancement at the group level will be identical to its effects on individual performance. For example, a factor that consistently impairs performance in individuals can be unproblematic when these individuals act in groups. And a factor that clearly enhances performance in individuals can even impair performance in groups. The reason is that such impairments and enhancements can affect the group-specific components of performance (i.e., lead to process gains or process losses).
- We cannot directly generalize findings on one impairment or enhancement to another, even if they have comparable effects on the individual level. The reason is that interpersonal psychological processes that are specific to a particular impairment or enhancement can come into play. For example, while one impairment

(such as fatigue) might not be altered in itself by working in a group, another (such as stress) might be attenuated by social interaction. And while one enhancement (such as a cup of coffee) might improve a group's performance over and above performance in individuals, another (such as a "smart pill") might potentially even act as an impairment for group performance.

- Methodologically, we recommend systematically analyzing the effects of the impairment or enhancement of interest with respect to three group-specific sources of process gains and losses: motivation, individual capability, and coordination. We further recommend using nominal group performance as the baseline with which to compare the actual groups' performance, and caution against trying to draw strong conclusions without such a baseline. When employing nominal group performance as baseline, statistical interaction patterns between the variables "nominal versus actual group performance" and "impairment/enhancement absent versus present" will result that can be interpreted to answer the question whether grouping hurts or helps for the impairment or enhancement of interest (cf. Figure 1 and Table 1).
- Investigating how individual-level impairments and enhancements affect performance when people act in groups, we need to be mindful about potential moderator variables (such as the strength of an impairment or enhancement, task characteristics, group size, and diversity in being impaired or enhanced). These can alter either the direct effects (i.e., on individual-specific components) or indirect effects (i.e., on group-specific components) of performance impairments and enhancements. In empirical research practice, we recommend first focusing on simple "default settings" for the group (such as small size), the performance task (such as a typical task), and the impairment or enhancement (such as a common dose of an enhancer).

We hope that our GIE framework can serve as a helpful model for tackling the question of how individual-level performance impairments and enhancements influence performance in groups. Such research would contribute to knowledge about how impairments and enhancements affect us in our social, collective activities, not only as isolated beings. And it could provide empirically grounded advice for practice on how to promote better group performance in an era of sleep deprivation and stress, use of caffeine and PCEs, and other consequences of our 24/7 lifestyle.

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Notes

1. This approach does not avoid all the confusions implicit in Steiner's model, though. For example, in a quantitative group judgment at a purely intellective task (e.g., estimating a room's temperature), as long as the correct solution is within the range of the group members' individual judgments, there may be several ways of aggregating these judgments that would arrive at an errorless solution. But it is not terribly useful to assert that the potential of all groups facing such tasks is an errorless performance. Rather, in such cases, one might want to set up and competitively test several alternative and psychologically plausible combination schemes (e.g., simple averaging, median model, using member experience or confidence or centrality to weigh estimates; cf. Davis, 1996).
2. Following the conceptualization of group performance we employ (cf. Schulz-Hardt & Brodbeck, 2015), when the nominal group potential is taken as the baseline, groups cannot show coordination gains, as the nominal group potential is based on an optimal combination of individual contributions. Note that in Steiner's (1972) conceptualization, group potential is based on the interacting, rather than the nominal, group and constitutes the upper limit for a group's performance, not allowing for process gains, as discussed here. In Steiner's model, Process Losses = Actual Productivity − Potential Productivity (for a more in-depth discussion, cf. Baron & Kerr, 2003).
3. Our conceptual hypotheses on sleep deprivation translate to the following statistical hypotheses, when taking the nominal group potential as the baseline for performance comparison. Hypothesis 1a: a three-way interaction of Sleep Deprivation (present/absent) × Group (nominal/actual) × Identifiability of Contributions (low/high). Hypothesis 1b: a two-way interaction of Sleep Deprivation (present/absent) × Group (nominal/actual), and a three-way interaction of Sleep Deprivation (present/absent) × Group (nominal/actual) × Awareness of Impairment (low/high), respectively. Hypothesis 1c: a three-way interaction of Sleep Deprivation (present/absent) × Group (nominal/actual) × Potential for Group Monitoring (low/high).
4. Note, however, that mistrust has also been found to lead to social compensation under certain conditions (Williams & Karau, 1991).
5. As mentioned in relation to motivation gains, caffeine can improve mood. Positive mood, in turn, has been suggested to

promote heuristic information processing (e.g., Park & Banaji, 2000). Even though this might suggest that caffeine could indirectly reduce gains in individual capability, we think that the direct effects caffeine has on memory and verbal processing are likely to outweigh such indirect effects on individual capability.

6. Our conceptual hypotheses on caffeine translate to the following statistical hypotheses, when taking the nominal group potential as the baseline for performance comparison. Hypothesis 2a: a two-way interaction of Dose of Caffeine (none/low or medium/high) × Group (nominal/actual), mediated by mood. Hypothesis 2b: a two-way interaction of Caffeine (yes/no) × Group (nominal/actual). Hypothesis 2c: a two-way interaction of Dose of Caffeine (none/low or medium/high) × Group (nominal/actual).
7. These motivation losses might be somewhat attenuated if the non-using group members perceive other members' use of pharmacological cognitive enhancements (PCEs) less as an illegitimate attempt to "boost smartness," and more as an acceptable attempt to compensate for an impairment of normal functioning (Cabrera, Fitz, & Reiner, 2014) or to increase work motivation (Faber, Douglas, Heise, & Hewstone, 2015).
8. Barnes and Hollenbeck (2009) suggested a taxonomy that combines McGrath's (1984) distinction between problem-solving and choice tasks with Laughlin and Ellis's (1986) task demonstrability. We agree with Barnes and Hollenbeck's suggestion that the reliance on divergent/prefrontal reasoning may be crucial for the effects of sleep deprivation, but we do not see a strong association between this factor and Barnes and Hollenbeck's taxonomy (e.g., one can easily think of tasks in each category that do and do not depend heavily on prefrontal cortex functioning). Moreover, there are several variables that act as individual-level impairments and enhancements, which affect neuro-cognitive functions differently from sleep deprivation—variables we are interested in in our general framework.
9. Note that with using the grouping helps versus grouping hurts terminology throughout this article, we laid our conceptual focus on group as the moderator, that is, on the question how acting in a group versus acting as an individual moderates the effect an impairment or an enhancement has on performance. From a statistical viewpoint, we propose interaction effects between impairment/enhancement (absent vs. present) and group (nominal vs. actual). Such an interaction could also be decomposed with a conceptual focus on impairment/enhancement as the moderator, that is, on the question how the presence versus absence of this impairment or enhancement moderates affects process gains and process losses. It is up to the researcher which focus to choose and the interaction patterns presented in Figure 1 can be read both ways.
10. This consistency between individual performance and nominal group performance is assumed in the following analyses of interaction patterns and in Table 1. Exceptions to this assumption are conceivable, but probably uncommon.

References

Abele, S., & Diehl, M. (2008). Finding team mates who are not prone to sucker and free-rider effects: The Protestant work ethic as a moderator of motivation losses in group performance. *Group Processes and Intergroup Relations*, *11*, 39-54. doi:10.1177/1368430207084845

Abrams, D., Hopthrow, T., Hulbert, L., & Frings, D. (2006). "Groupdrink"? The effect of alcohol on risk attraction among groups versus individuals. *Journal of Studies on Alcohol and Drugs*, *67*, 628-636.

Åkerstedt, T. (1998). Shift work and disturbed sleep/wakefulness. *Sleep Medicine Reviews*, *2*, 117-128. doi:10.1016/S1087-0792(98)90004-1

Alhola, P., & Polo-Kantola, P. (2007). Sleep deprivation: Impact on cognitive performance. *Neuropsychiatric Disease and Treatment*, *3*, 553-567.

Anderson, C., & Dickinson, D. L. (2010). Bargaining and trust: The effects of 36-h total sleep deprivation on socially interactive decisions. *Journal of Sleep Research*, *19*, 54-63. doi:10.1111/j.1365-2869.2009.00767.x

Anderson, C., & Platten, C. R. (2011). Sleep deprivation lowers inhibition and enhances impulsivity to negative stimuli. *Behavioural Brain Research*, *217*, 463-466. doi:10.1016/j.bbr.2010.09.020

Bahrami, B., Olsen, K., Latham, P. E., Roepstorff, A., Rees, G., & Frith, C. D. (2010). Optimally interacting minds. *Science*, *329*, 1081-1085. doi:10.1126/science.1185718

Baranski, J. V. (2007). Fatigue, sleep loss, and confidence in judgment. *Journal of Experimental Psychology: Applied*, *13*, 182-196. doi:10.1037/1076-898X.13.4.182

Baranski, J. V., Thompson, M. M., Lichacz, F. M. J., McCann, C., Gil, V., Pastò, L., & Pigeau, R. A. (2007). Effects of sleep loss on team decision making: Motivational loss or motivational gain? *Human Factors*, *49*, 646-660. doi:10.1518/001872007X215728

Barnes, C. M. (2011). I'll sleep when I'm dead: Managing those too busy to sleep. *Organizational Dynamics*, *40*, 18-26. doi:10.1016/j.orgdyn.2010.10.001

Barnes, C. M., Guina, B. C., & Wagner, D. T. (2015). Sleep and moral awareness. *Journal of Sleep Research*, *24*, 181-188. doi:10.1111/jsr.12231

Barnes, C. M., & Hollenbeck, J. R. (2009). Sleep deprivation and decision-making teams: Burning the midnight oil or playing with fire? *Academy of Management Review*, *34*, 56-66. doi:10.5465/AMR.2009.35713280

Barnes, C. M., Schaubroeck, J., Huth, M., & Ghumman, S. (2011). Lack of sleep and unethical conduct. *Organizational Behavior and Human Decision Processes*, *115*, 169-180. doi:10.1016/j.obhdp.2011.01.009

Barnes, C. M., & Wagner, D. T. (2009). Changing to daylight saving time cuts into sleep and increases workplace injuries. *Journal of Applied Psychology*, *94*, 1305-1317. doi:10.1037/a0015320

Baron, R. S., & Kerr, N. L. (2003). *Group process, group decision, group action* (2nd ed.). Buckingham, UK: Open University Press.

Barone, J. J., & Roberts, H. R. (1996). Caffeine consumption. *Food and Chemical Toxicology*, *34*, 119-129. doi:10.1016/0278-6915(95)00093-3

Battleday, R. M., & Brem, A.-K. (2015). Modafinil for cognitive neuroenhancement in healthy non-sleep-deprived subjects: A systematic review. *European Neuropsychopharmacology*. Advance online publication. doi:10.1016/j.euroneuro.2015.07.028

Baumeister, R. F., Ainsworth, S. E., & Vohs, K. D. (2015). Are groups more or less than the sum of their members? The moderating role of individual identification. *Behavioral and Brain Sciences*. Advance online publication. doi:10.1017/S0140525X15000618

Baumeister, R. F., Bratslavsky, E., Muraven, M., & Tice, D. M. (1998). Ego depletion: Is the active self a limited resource? *Journal of Personality and Social Psychology*, *74*, 1252-1265. doi:10.1037/0022-3514.74.5.1252

Berger, J. (2011). Arousal increases social transmission of information. *Psychological Science*, *22*, 891-893. doi:10.1177/0956797611413294

Borota, D., Murray, E., Keceli, G., Chang, A., Watabe, J. M., Ly, M., . . . Yassa, M. A. (2014). Post-study caffeine administration enhances memory consolidation in humans. *Nature Neuroscience*, *17*, 201-203. doi:10.1038/nn.3623

Bostrom, N., & Sandberg, A. (2009). Cognitive enhancement: Methods, ethics, regulatory challenges. *Science and Engineering Ethics*, *15*, 311-341. doi:10.1007/s11948-009-9142-5

Brunye, T. T., Mahoney, C. R., Lieberman, H. R., Giles, G. E., & Taylor, H. A. (2010). Acute caffeine consumption enhances the executive control of visual attention in habitual consumers. *Brain Cognition*, *74*, 186-192. doi:10.1016/j.bandc.2010.07.006

Cabrera, L., Fitz, N. S., & Reiner, P. B. (2014). Empirical support for the moral salience of the therapy-enhancement distinction in the debate over cognitive, affective and social enhancement. *Neuroethics*, *7*, 1-14. doi:10.1007/s12152-014-9223-2

Casas, M., Ramos-Quiroga, J. A., Prat, G., & Qureshi, A. (2004). Effects of coffee and caffeine on mood and mood disorders. In A. Nehlig (Ed.), *Coffee, tea, chocolate, and the brain* (pp. 74-84). New York, NY: Taylor & Francis. doi:10.1201/9780203618851

Caviola, L., Mannino, A., Savulescu, J., & Faulmüller, N. (2014). Cognitive biases can affect moral intuitions about cognitive enhancement. *Frontiers in Systems Neuroscience*, *8*, 195. doi:10.3389/fnsys.2014.00195

Centers for Disease Control and Prevention. (2015). *Insufficient sleep is a public health epidemic*. Retrieved from http://www.cdc.gov/features/dssleep/

Chatzitheochari, S., & Arber, S. (2009). Lack of sleep, work and the long hours culture: Evidence from the UK Time Use Survey. *Work, Employment & Society*, *23*, 30-48. doi:10.1177/0950017008099776

Chee, M. W., & Choo, W. C. (2004). Functional imaging of working memory after 24 hr of total sleep deprivation. *The Journal of Neuroscience*, *24*, 4560-4567. doi:10.1523/JNEUROSCI.0007-04.2004

Christian, M. S., & Ellis, A. P. J. (2011). Examining the effects of sleep deprivation on workplace deviance: A self-regulatory perspective. *Academy of Management Journal*, *54*, 913-934. doi:10.5465/amj.2010.0179

Cohen, S., & McKay, G. (1984). Social support, stress and the buffering hypothesis: A theoretical analysis. In A. Baum, J. E. Singer, & S. E. Taylor (Eds.), *Handbook of psychology and health* (pp. 253-267). Hillsdale, NJ: Lawrence Erlbaum.

Couyoumdjian, A., Sdoia, S., Tempesta, D., Curcio, G., Rastellini, E., De Gennaro, L., & Ferrara, M. (2010). The effects of sleep and sleep deprivation on task-switching performance. *Journal of Sleep Research*, *19*, 64-70. doi:10.1111/j.1365-2869.2009.00774.x

Davis, J. H. (1996). Group decision making and quantitative judgments: A consensus model. In E. H. Witte & J. H. Davis (Eds.), *Understanding group behavior: Consensual action by small groups* (Vol. 1, pp. 35-59). Mahwah, NJ: Lawrence Erlbaum.

De Dreu, C. K. W. (2003). Time pressure and closing of the mind in negotiation. *Organizational Behavior and Human Decision Processes*, *91*, 280-295. doi:10.1016/S0749-5978(03)00022-0

De Dreu, C. K. W., Nijstad, B. A., & van Knippenberg, D. (2008). Motivated information processing in group judgment and decision making. *Personality and Social Psychology Review*, *12*, 22-49. doi:10.1177/1088868307304092

Dennis, A. R. (1996). Information exchange and use in small group decision making. *Small Group Research*, *27*, 532-550. doi:10.1177/1046496496274003

DeRosa, D. M., Smith, C. L., & Hantula, D. A. (2007). The medium matters: Mining the long-promised merit of group interaction in creative idea generation tasks in a meta-analysis of the electronic group brainstorming literature. *Computers in Human Behavior*, *23*, 1549-1581. doi:10.1016/j.chb.2005.07.003

Diehl, M., & Stroebe, W. (1987). Productivity loss in brainstorming groups: Toward the solution of a riddle. *Journal of Personality and Social Psychology*, *53*, 497-509. doi:10.1037/0022-3514.61.3.392

Dinges, D. F. (1995). An overview of sleepiness and accidents. *Journal of Sleep Research*, *4*(S2), 4-14. doi:10.1111/j.1365-2869.1995.tb00220.x

Ditzen, B., Schmidt, S., Strauss, B., Nater, U. M., Ehlert, U., & Heinrichs, M. (2008). Adult attachment and social support interact to reduce psychological but not cortisol responses to stress. *Journal of Psychosomatic Research*, *64*, 479-486. doi:10.1016/j.jpsychores.2007.11.011

Dorrian, J., Lamond, N., & Dawson, D. (2000). The ability to self-monitor performance when fatigued. *Journal of Sleep Research*, *9*, 137-144. doi:10.1046/j.1365-2869.2000.00195.x

Drummond, S. P., Paulus, M. P., & Tapert, S. F. (2006). Effects of two nights sleep deprivation and two nights recovery sleep on response inhibition. *Journal of Sleep Research*, *15*, 261-265. doi:10.1111/j.1365-2869.2006.00535.x

Durmer, J. S., & Dinges, D. F. (2005). Neurocognitive consequences of sleep deprivation. *Seminars in Neurology*, *25*, 117-129. doi:10.1055/s-0029-1237117

Einöther, S. J., & Giesbrecht, T. (2013). Caffeine as an attention enhancer: Reviewing existing assumptions. *Psychopharmacology*, *225*, 251-274. doi:10.1007/s00213-012-2917-4

Elliott, R., Sahakian, B. J., Matthews, K., Bannerjea, A., Rimmer, J., & Robbins, T. W. (1997). Effects of methylphenidate on spatial working memory and planning in healthy young adults. *Psychopharmacology*, *131*, 196-206. doi:10.1007/s002130050284

Evans, D. R., Boggero, I. A., & Segerstrom, S. C. (2015). The nature of self-regulatory fatigue and "ego depletion" lessons from physical fatigue. *Personality and Social Psychology Review*. Advance online publication. doi:10.1177/1088868315597841

Faber, N. S., Douglas, T., Heise, F., & Hewstone, M. (2015). Cognitive enhancement and motivation enhancement: An empirical comparison of intuitive judgments. *AJOB Neuroscience*, *13*, 18-20. doi:10.1080/21507740.2014.991847

Faber, N. S., Savulescu, J., & Douglas, T. (2015). *Why is cognitive enhancement deemed unacceptable? The role of fairness, deservingness, and hollow achievements*. Manuscript submitted for publication.

Faber, N. S., Savulescu, J., & Van Lange, P. A. M. (in press). Reputational concerns as a general determinant of group functioning. *Behavioral and Brain Sciences*.

Falleti, M. G., Maruff, P., Collie, A., Darby, D. G., & McStephen, M. (2003). Qualitative similarities in cognitive impairment associated with 24 h of sustained wakefulness and a blood alcohol concentration of 0.05%. *Journal of Sleep Research*, *12*, 265-274. doi:10.1111/j.1365-2869.2003.00363.x

Faulmüller, N., Kerschreiter, R., Mojzisch, A., & Schulz-Hardt, S. (2010). Beyond group-level explanations for the failure of groups to solve hidden profiles: The individual preference effect revisited. *Group Processes and Intergroup Relations*, *13*, 653-671. doi:10.1177/1368430210369143

Faulmüller, N., Maslen, H., & Santoni de Sio, F. (2013). The indirect psychological costs of cognitive enhancement. *The American Journal of Bioethics*, *13*, 45-47. doi:10.1080/15265161.2013.794880

Faulmüller, N., Mojzisch, A., Kerschreiter, R., & Schulz-Hardt, S. (2012). Do you want to convince me or to be understood? Preference-consistent information sharing and its motivational determinants. *Personality and Social Psychology Bulletin*, *38*, 1685-1697. doi:10.1177/0146167212458707

Ferre, S. (2008). An update on the mechanisms of the psychostimulant effects of caffeine. *Journal of Neurochemistry*, *105*, 1067-1079. doi:10.1111/j.1471-4159.2007.05196.x

Franke, A. G., Bagusat, C., Dietz, P., Hoffmann, I., Simon, P., Ulrich, R., & Lieb, K. (2013). Use of illicit and prescription drugs for cognitive or mood enhancement among surgeons. *BMC Medicine, 11*, Article 102. doi:10.1186/1741-7015-11-102

Frary, C. D., Johnson, R. K., & Wang, M. Q. (2005). Food sources and intakes of caffeine in the diets of persons in the United States. *Journal of the American Dietetic Association*, *105*, 110-113. doi:10.1016/j.jada.2004.10.027

Frings, D. (2011). The effects of group monitoring on fatigue-related einstellung during mathematical problem solving. *Journal of Experimental Psychology: Applied*, *17*, 371-381. doi:10.1037/a0025131

Frings, D. (2015). The effects of low levels of fatigue on face recognition among individuals and team members. *Journal of Applied Social Psychology*, *45*, 461-470. doi:10.1111/jasp.12312

Frings, D., Hopthrow, T., Abrams, D., Hulbert, L., & Gutierrez, R. (2008). Groupdrink: The effects of alcohol and group process on vigilance errors. *Group Dynamics: Theory, Research, and Practice*, *12*, 179-190. doi:10.1037/1089-2699.12.3.179

Frisch, J. U., Häusser, J. A., & Mojzisch, A. (2015). The Trier Social Stress Test as a paradigm to study how people respond to threat in social interactions. *Frontiers in Psychology*, *6*, 14. doi:10.3389/fpsyg.2015.00014

Frisch, J. U., Häusser, J. A., van Dick, R., & Mojzisch, A. (2014). Making support work: The interplay between social support and social identity. *Journal of Experimental Social Psychology*, *55*, 154-161. doi:10.1016/j.jesp.2014.06.009

Gordon, A. M., & Chen, S. (2014). The role of seep in interpersonal conflict: Do sleepless nights mean worse fights? *Social Psychological and Personality Science*, *5*, 168-175. doi:10.1177/1948550613488952

Greely, H., Sahakian, B. J., Harris, J., Kessler, R. C., Gazzaniga, M., Campbell, P., & Farah, M. J. (2008). Towards responsible use of cognitive enhancing drugs by the healthy. *Nature*, *456*, 702-705. doi:10.1038/456702a

Green, P. J., & Suls, J. (1996). The effects of caffeine on ambulatory blood pressure, heart rate, and mood. *Journal of Behavioral Medicine*, *19*, 111-128. doi:10.1007/BF01857602

Greitemeyer, T., & Schulz-Hardt, S. (2003). Preference-consistent evaluation of information in the hidden profile paradigm: Beyond group-level explanations for the dominance of shared information in group decisions. *Journal of Personality and Social Psychology*, *84*, 322-339. doi:10.1037/0022-3514.84.2.322

Gupta, U. (1991). Differential effects of caffeine on free recall after semantic and rhyming tasks in high and low impulsives. *Psychopharmacology*, *105*, 137-140. doi:10.1007/BF02316878

Hackman, J. R. (1968). Effects of task characteristics on group products. *Journal of Experimental Social Psychology*, *4*, 162-187. doi:10.1016/0022-1031(68)90040-1

Hackman, J. R. (1969). Toward understanding the role of tasks in behavioral research. *Acta Psychologica*, *31*, 97-128. doi:10.1016/0001-6918(69)90073-0

Hackman, J. R., & Morris, C. G. (1975). Group tasks, group interaction process, and group performance effectiveness: A review and proposed integration. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 8, pp. 45-99). New York, NY: Academic Press. doi:10.1016/S0065-2601(08)60248-8

Hadjicharalambous, M., Georgiades, E., Kilduff, L. P., Turner, A. P., Tsofliou, F., & Pitsiladis, Y. P. (2006). Influence of caffeine on perception of effort, metabolism and exercise performance following a high-fat meal. *Journal of Sports Science*, *24*, 875-887. doi:10.1080/02640410500249399

Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. (2010). Ego depletion and the strength model of self-control: A meta-analysis. *Psychological Bulletin*, *136*, 495-525. doi:10.1037/a0019486

Harkins, S., & Petty, R. E. (1982). Effects of task difficulty and task uniqueness on social loafing. *Journal of Personality and Social Psychology*, *43*, 1214-1230. doi:10.1037/0022-3514.43.6.1214

Harrison, Y., & Horne, J. A. (2000). The impact of sleep deprivation on decision making: A review. *Journal of Experimental Psychology: Applied*, *6*, 236-249. doi:10.1037/1076-898X.6.3.236

Harrison, Y., Horne, J. A., & Rothwell, A. (2000). Prefrontal neuropsychological effects of sleep deprivation in young adults: A model for healthy aging? *Sleep*, *23*, 1067-1073.

Hasenfratz, M., & Bättig, K. (1994). Acute dose-effect relationships of caffeine and mental performance, EEG, cardiovascular and subjective parameters. *Psychopharmacology*, *114*, 281-287. doi:10.1007/BF02244850

Haslam, S. A. (2004). *Psychology in organizations: The social identity approach* (2nd ed.). London, England: SAGE.

Haslam, S. A., Jetten, J., Postmes, T., & Haslam, C. (2009). Social identity, health and wellbeing: An emerging agenda for applied psychology. *Applied Psychology: An International Review*, *58*, 1-23. doi:10.1111/j.1464-0597.2008.00379.x

Haslam, S. A., Jetten, J., & Waghorn, C. (2009). Social identification, stress and citizenship in teams: A five-phase longitudinal study. *Stress and Health*, *25*, 21-30. doi:10.1002/smi.1221

Haslam, S. A., O'Brien, A., Jetten, J., Vormedal, K., & Penna, S. (2005). Taking the strain: Social identity, social support and the experience of stress. *British Journal of Social Psychology*, *44*, 355-370. doi:10.1348/014466605X37468

Häusser, J. A., Kattenstroth, M., van Dick, R., & Mojzisch, A. (2012). "We" are not stressed: Social identity in groups buffers neuroendocrine stress reactions. *Journal of Experimental Social Psychology*, *48*, 973-977. doi:10.1016/j.jesp. 2012.*02*.020

Häusser, J. A., Schlemmer, A., Kaiser, S., Kalis, A., & Mojzisch, A. (2014). The effects of caffeine on option generation and subsequent choice. *Psychopharmacology*, *231*, 3719-3727. doi:10.1007/s00213-014-3506-5

Heatherley, S. V., Hayward, R. C., Seers, H. E., & Rogers, P. J. (2005). Cognitive and psychomotor performance, mood, and pressor effects of caffeine after 4, 6 and 8 h caffeine abstinence. *Psychopharmacology*, *178*, 461-470. doi:10.1007/s00213-005-2159-9

Heinrichs, M., Baumgartner, T., Kirschbaum, C., & Ehlert, U. (2003). Social support and oxytocin interact to suppress cortisol and subjective responses to psychosocial stress. *Biological Psychiatry*, *54*, 1389-1398. doi:10.1016/S0006-3223(03)00465-7

Hirshkowitz, M., Whiton, K., Albert, S. M., Alessi, C., Bruni, O., DonCarlos, L., . . . Adams Hillard, P. J. (2015). National Sleep Foundation's sleep time duration recommendations: Methodology and results summary. *Sleep Health*, *1*, 40-43. doi:10.1016/j.sleh.2014.12.010

Hobson, J. A. (2005). Sleep is of the brain, by the brain and for the brain. *Nature*, *437*, 1254-1256. doi:10.1038/nature04283

Hockey, G. R. J. (1997). Compensatory control in the regulation of human performance under stress and high workload: A cognitive-energetical framework. *Biological Psychology*, *45*, 73-93. doi:10.1016/S0301-0511(96)05223-4

Hockey, G. R. J. (2011). A motivational control theory of cognitive fatigue. In P. L. Ackerman (Ed.), *Cognitive fatigue: Multidisciplinary perspectives on current research and future applications* (pp. 167-188). Washington, DC: American Psychological Association.

Hockey, G. R. J. (2013). *Psychology of fatigue*. New York, NY: Cambridge University Press.

Hoeksma-van Orden, C. Y. D., Gaillard, A. W. K., & Buunk, B. P. (1998). Social loafing under fatigue. *Journal of Personality and Social Psychology*, *75*, 1179-1190. doi:10.1037/0022-3514.75.5.1179

Hoever, I. J., van Knippenberg, D., van Ginkel, W. P., & Barkema, H. G. (2012). Fostering team creativity: Perspective taking as key to unlocking diversity's potential. *Journal of Applied Psychology*, *97*, 982-996. doi:10.1037/a0029159

Hogervorst, E., Riedel, W. J., Schmitt, J. A. J., & Jolles, J. (1998). Caffeine improves memory performance during distraction in middle-aged, but not in young or old subjects. *Human Psychopharmacology*, *13*, 277-284. doi:10.1002/(SICI)1099-1077(199806)13:4<277::AID-HUP996>3.0.CO;2-W

Hollingworth, H. L. (1912). The influence of caffeine on motor and mental efficiency. *Archives of Psychology*, *22*, 1-166.

Hopthrow, T., de Moura, R., Meleady, R., Abrams, D., & Swift, H. J. (2014). Drinking in social groups. Does "groupdrink" provide safety in numbers when deciding about risk? *Addiction*, *109*, 913-921. doi:10.1111/add.12496

Horne, J. (1988a). Sleep loss and "divergent" thinking ability. *Sleep*, *11*, 528-536.

Horne, J. (1988b). *Why we sleep: The functions of sleep in humans and other mammals*. Oxford, UK: Oxford University Press.

Huang, Z., Qu, W., Eguchi, N., Chen, J., Schwarzschild, M. A., Fredholm, B. B., . . . Hayaishi, O. (2005). Adenosine A2A, but not A1, receptors mediate the arousal effect of caffeine. *Nature Neuroscience*, *8*, 858-859. doi:10.1038/nn1491

Hülsheger, U. R., Anderson, N., & Salgado, J. F. (2009). Team-level predictors of innovation at work: A comprehensive meta-analysis spanning three decades of research. *Journal of Applied Psychology*, *94*, 1128-1145. doi:10.1037/a0015978

Husain, M., & Mehta, M. A. (2011). Cognitive enhancement by drugs in health and disease. *Trends in Cognitive Sciences*, *15*, 28-36. doi:10.1016/j.tics.2010.11.002 21146447

Ilgen, D. R., Hollenbeck, J. R., Johnson, M., & Jundt, D. (2005). Teams in organizations: From input-process-output models to IMOI models. *Annual Review of Psychology*, *56*, 517-543. doi:10.1146/annurev.psych.56.091103.070250

Ilieva, I. P., Boland, J., & Farah, M. J. (2013). Objective and subjective cognitive enhancing effects of mixed amphetamine salts in healthy people. *Neuropharmacology*, *64*, 496-505. doi:10.1016/j.neuropharm.2012.07.021

Ilieva, I. P., Hook, C. J., & Farah, M. J. (2015). Prescription stimulants' effects on healthy inhibitory control, working memory, and episodic memory: A meta-analysis. *Journal of Cognitive Neuroscience*, *27*, 1069-1089. doi:10.1162/jocn_a_00776

Ilkowska, M., & Engle, R. W. (2010). Trait and state differences in working memory capacity. In A. Gruszka, G. Matthews, & B. Szymura (Eds.), *Handbook of individual differences in cognition* (pp. 295-320). New York, NY: Springer. doi:10.1007/978-1-4419-1210-7_18

Jackson, C. L., & LePine, J. A. (2003). Peer responses to a team's weakest link: A test and extension of LePine and Van Dyne's model. *Journal of Applied Psychology*, *88*, 459-475. doi:10.1037/0021-9010.88.3.459

Jackson, E. J., & Moreton, A. (2013). Safety during night shifts: A cross-sectional survey of junior doctors' preparation and practice. *BMJ Open, 3*, Article e003567. doi:10.1016/j.physbeh.2013.07.002

Janis, I. L. (1982). *Groupthink* (2nd ed.). Boston, MA: Houghton Mifflin.

Karau, S. J., & Williams, K. D. (1993). Social loafing: A meta-analytic review and theoretical integration. *Journal of Personality and Social Psychology*, *65*, 681-706. doi:10.1037/0022-3514.65.4.681

Kenny, D. A., Mannetti, L., Pierro, A., Livi, S., & Kashy, D. A. (2002). The statistical analysis of data from small groups. *Journal of Personality and Social Psychology*, *83*, 126-137. doi:10.1037/0022-3514.83.1.126

Kerr, N. L. (1983). Motivation losses in task-performing groups: A social dilemma analysis. *Journal of Personality and Social Psychology*, *45*, 819-828. doi:10.1037/0022-3514.45.4.819

Kerr, N. L. (2009). Group task. In J. M. Levine & M. A. Hogg (Eds.), *Encyclopedia of group processes and intergroup relations*. Thousand Oaks, CA: SAGE.

Kerr, N. L., & Bruun, S. E. (1983). Dispensability of member effort and group motivation losses: Free-rider effects.

Journal of Personality and Social Psychology, *44*, 78-94. doi:10.1037/0022-3514.44.1.78

Kerr, N. L., & Hertel, G. (2011). The Köhler Group motivation gain: How to motivate the "Weak Links" in a group. *Social and Personality Psychology Compass*, *5*, 43-55. doi:10.1111/j.1751-9004.2010.00333.x

Kerr, N. L., & Seok, D. (2011). " . . . with a little help from my friends": Friendship, effort norms, and group motivation gain. *Journal of Managerial Psychology*, *26*, 205-218. doi:10.1108/02683941111112640

Kerr, N. L., & Tindale, R. S. (2004). Group performance and decision making. *Annual Review of Psychology*, *55*, 623-655. doi:10.1146/annurev.psych.55.090902.142009

Kerr, N. L., & Tindale, R. S. (2014). Methods of small group research. In H. Reis & C. Judd (Eds.), *Research methods in social psychology: A handbook* (2nd ed.; pp. 188-219). New York, NY: Cambridge University Press.

Killgore, W. D., Balkin, T. J., & Wesensten, N. J. (2006). Impaired decision making following 49 h of sleep deprivation. *Journal of Sleep Research*, *15*, 7-13. doi:10.1111/j.1365-2869.2006.00487.x

Killgore, W. D., Lipizzi, E. L., Kamimori, G. H., & Balkin, T. J. (2007). Caffeine effects on risky decision making after 75 hours of sleep deprivation. *Aviation, Space, and Environmental Medicine*, *78*, 957-962. doi:10.3357/ASEM.2106.2007

Kirschbaum, C., Klauer, T., Filipp, S. H., & Hellhammer, D. H. (1995). Sex-specific effects of social support on cortisol and subjective responses to acute psychological stress. *Psychosomatic Medicine*, *57*, 23-31.

Kohn, N. W., Paulus, P. B., & Choi, Y. (2011). Building on the ideas of others: An examination of the idea combination process. *Journal of Experimental Social Psychology*, *47*, 554-561. doi:10.1016/j.jesp.2011.01.004

Kohn, N. W., & Smith, S. M. (2011). Collaborative fixation: Effects of others' ideas on brainstorming. *Applied Cognitive Psychology*, *25*, 359-371. doi:10.1002/acp.1699

Koriat, A. (2012). When are two heads better than one and why? *Science*, *336*, 360-362. doi:10.1126/science.1216549

Kruglanski, A. W., & Webster, D. M. (1996). Motivated closing of the mind: "Seizing" and "freezing. *Psychological Review*, *103*, 263-283. doi:10.1037/0033-295X.103.2.263

Larson, J. R. (2010). *In search of synergy in small group performance*. Hove, UK: Psychology Press.

Latané, B. (1981). The psychology of social impact. *American Psychologist*, *36*, 343-356. doi:10.1037/0003-066X.36.4.343

Latané, B., Williams, K., & Harkins, S. (1979). Many hands make light the work: The causes and consequences of social loafing. *Journal of Personality and Social Psychology*, *37*, 822-832. doi:10.1037/0022-3514.37.6.822

Laughlin,P.R.,Carey,H.R.,&Kerr,N.L.(2008).Group-to-individual problem solving transfer. *Group Processes and Intergroup Relations*, *11*, 319-330. doi:10.1177/1368430208090645

Laughlin, P. R., & Ellis, A. L. (1986). Demonstrability and social combination processes on mathematical intellective tasks. *Journal of Experimental Social Psychology*, *22*, 177-189. doi:10.1016/0022-1031(86)90022-3

Lazarus, R. S. (1974). Psychological stress and coping in adaptation and illness. *International Journal of Psychiatry in Medicine*, *5*, 321-333. doi:10.2190/T43T-84P3-QDUR-7RTP

Leder, J., Häusser, J. A., & Mojzisch, A. (2013). Stress and strategic decision-making in the beauty contest game. *Psychoneuroendocrinology*, *38*, 1503-1511. doi:10.1016/j.psyneuen.2012.12.016

Leder, J., Häusser, J. A., & Mojzisch, A. (2015). Exploring the underpinnings of impaired strategic decision-making under stress. *Journal of Economic Psychology*, *49*, 133-140. doi:10.1016/j.joep.2015.05.006

Levine, J. M., & Moreland, R. L. (1990). Progress in small group research. *Annual Review of Psychology*, *41*, 585-634. doi:10.1146/annurev.psych.41.1.585

Lewin, K. (1947). Frontiers in group dynamics: Concept, method and reality in social science; social equilibria and social change. *Human Relations*, *1*, 5-41. doi:10.1177/001872674700100103

Lieberman, H. R. (1992). Caffeine. In A. P. Smith & D. M. Jones (Eds.), *Handbook of human performance* (Vol. *2*, pp. 49-72). London, England: Academic Press.

Lieberman, H. R., Tharion, W. J., Shukitt-Hale, B., Speckman, K. L., & Tulley, R. (2002). Effects of caffeine, sleep loss, and stress on cognitive performance and mood during US Navy SEAL training. *Psychopharmacology*, *164*, 250-261. doi:10.1007/s00213-002-1217-9

Lieberman, H. R., Wurtman, R. J., Emde, G. G., Roberts, C., & Coviella, I. L. (1987). The effects of low doses of caffeine on human performance and mood. *Psychopharmacology*, *92*, 308-312. doi:10.1007/BF00210835

Liguori, A., Hughes, J. R., & Grass, J. A. (1997). Absorption and subjective effects of caffeine from coffee, cola and capsules. *Pharmacology, Biochemistry and Behavior*, *58*, 721-726. doi:10.1016/S0091-3057(97)00003-8

Locke, E. A., Tirnauer, D., Roberson, Q. M., Goldman, B., Latham, M. E., & Weldon, E. (2001). The importance of the individual in an age of groupism. In M. E. Turner (Ed.), *Groups at work: Theory and research* (pp. 501-528). Mahwah, NJ: Lawrence Erlbaum.

Lorge, I., & Solomon, H. (1955). Two models of group behavior in the solution of eureka-type problems. *Psychometrika*, *20*, 139-148. doi:10.1007/BF02288986

Lu, L., Yuan, Y. C., & McLeod, P. L. (2011). Twenty-five years of hidden profile studies in group decision making: A meta-analysis. *Personality and Social Psychology Review*, *16*, 54-75. doi:10.1177/1088868311417243

Maher, B. (2008). Poll results: Look who's doping. *Nature*, *452*, 674-675. doi:10.1038/452674a

Mannix, E., & Neale, M. A. (2005). What differences make a difference? The promise and reality of diverse teams in organizations. *Psychological Science in the Public Interest*, *6*, 31-55. doi:10.1111/j.1529-1006.2005.00022.x

Maridakis, V., Herring, M. P., & O'Connor, P. J. (2009). Sensitivity to change in cognitive performance and mood measures of energy and fatigue in response to differing doses of caffeine or breakfast. *International Journal of Neuroscience*, *119*, 975-994. doi:10.1080/00207450802333995

Martin, P. Y., Laing, J., Martin, R., & Mitchell, M. (2005). Caffeine, cognition, and persuasion: Evidence for caffeine increasing the systematic processing of persuasive messages. *Journal of Applied Social Psychology*, *35*, 160-182. doi:10.1111/j.1559-1816.2005.tb02098.x

Martins, L. L., Gilson, L. L., & Maynard, M. T. (2004). Virtual teams: What do we know and where do we go from here?

Journal of Management, *30*, 805-835. doi:10.1016/j.jm.2004.05.002

Maslen, H., Faulmüller, N., & Savulescu, J. (2014). Pharmacological cognitive enhancement—How neuroscientific research could advance ethical debate. *Frontiers in Systems Neuroscience*, *8*, 107. doi:10.3389/fnsys.2014.00107

Maslen, H., Santoni de Sio, F., & Faber, N. S. (2015). With cognitive enhancement comes great responsibility? In B.-J. Koops, I. Oosterlaken, H. Romijn, T. Swierstra, & J. van den Hoven (Eds.), *Responsible innovation 2—Concepts, approaches, and applications* (pp. 121-138). Cham, Switzerland: Springer International. doi:10.1007/978-3-319-17308-5_7

McGrath, J. E. (1984). A typology of tasks. In J. E. McGrath (Ed.), *Groups: Interaction and performance* (pp. 53-66). Englewood Cliffs, NJ: Prentice Hall.

McMenamin, T. M. (2007). A time to work: Recent trends in shift work and flexible schedules. *Monthly Labor Review*, *130*, 3-15.

Mehta, M. A., Owen, A. M., Sahakian, B. J., Mavaddat, N., Pickard, J. D., & Robbins, T. W. (2000). Methylphenidate enhances working memory by modulating discrete frontal and parietal lobe regions in the human brain. *Journal of Neuroscience*, *20*, 1-6.

Merz, C. J., Wolf, O. T., & Hennig, J. (2010). Stress impairs retrieval of socially relevant information. *Behavioral Neuroscience*, *124*, 288-293. doi:10.1037/a0018942

Mintz, P. M., & Mills, J. (1971). Effects of arousal and information about its source upon attitude change. *Journal of Experimental Social Psychology*, *7*, 561-570. doi:10.1016/0022-1031(71)90019-9

Miyata, S., Noda, A., Ozaki, N., Hara, Y., Minoshima, M., Iwamoto, K., . . . Koike, Y. (2010). Insufficient sleep impairs driving performance and cognitive function. *Neuroscience Letters*, *469*, 229-233. doi:10.1016/j.neulet.2009.12.001

Mojzisch, A., Kerschreiter, R., Faulmüller, N., Vogelgesang, F., & Schulz-Hardt, S. (2014). The consistency principle in interpersonal communication: Consequences of preference confirmation and disconfirmation in collective decision-making. *Journal of Personality and Social Psychology*, *106*, 961-977. doi:10.1037/a0036338

Mullen, B., Johnson, C., & Salas, E. (1991). Productivity loss in brainstorming groups: A meta-analytic integration. *Basic and Applied Social Psychology*, *12*, 3-23. doi:10.1207/s15324834basp1201_1

Müller, U., Steffenhagen, N., Regenthal, R., & Bublak, P. (2004). Effects of modafinil on working memory processes in humans. *Psychopharmacology*, *177*, 161-169. doi:10.1007/s00213-004-1926-3

Nehlig, A. (1999). Are we dependent upon coffee and caffeine? A review on human and animal data. *Neuroscience & Biobehavioral Reviews*, *23*, 563-576. doi:10.1016/S0149-7634(98)00050-5

Nehlig, A. (2004). *Coffee, tea, chocolate and the brain*. New York, NY: Taylor & Francis. doi:10.1201/9780203618851

Nehlig, A. (2010). Is caffeine a cognitive enhancer? *Journal of Alzheimer's Disease*, *20*, S85-S94. doi:10.3233/JAD-2010-091315

Nezlek, J. B. (2008). An introduction to multilevel modeling for social and personality psychology. *Social and Personality Psychology Compass*, *2*, 842-860. doi:10.1111/j.1751-9004.2007.00059.x

Nijstad, B. A., & Stroebe, W. (2006). How the group affects the mind: A cognitive model of idea generation in groups. *Personality and Social Psychology Review*, *10*, 186-213. doi:10.1207/s15327957pspr1003_1

Nijstad, B. A., Stroebe, W., & Lodewijkx, H. F. M. (2002). Cognitive stimulation and interference in groups: Exposure effects in an idea generation task. *Journal of Experimental Social Psychology*, *38*, 535-544. doi:10.1016/S0022-1031(02)00500-0

Osborn, A. F. (1957). *Applied imagination* (2nd ed.). New York, NY: Scribner.

Park, J., & Banaji, M. R. (2000). Mood and heuristics: The influence of happy and sad states on sensitivity and bias in stereotyping. *Journal of Personality and Social Psychology*, *78*, 1005-1023. doi:10.1037/0022-3514.78.6.1005

Paulus, P. B., & Yang, H. C. (2000). Idea generation in groups: A basis for creativity in organizations. *Organizational Behavior and Human Decision Processes*, *82*, 76-87. doi:10.1006/obhd.2000.2888

Philip, P., Chaufton, C., Orriols, L., Lagarde, E., Amoros, E., Laumon, B., . . . Sagaspe, P. (2014). Complaints of poor sleep and risk of traffic accidents: A population-based case-control study. *PLoS ONE*, *9*, e114102. doi:10.1371/journal.pone.0114102

Postmes, T., & Spears, R. (1998). Deindividuation and antinormative behavior: A metaanalysis. *Psychological Bulletin*, *123*, 238-259. doi:10.1037/0033-2909.123.3.238

Price, W. J., & Holley, D. C. (1990). Shiftwork and safety in aviation. *Occupational Medicine*, *5*, 343-377.

Quinlan, P. T., Lane, J., Moore, K. L., Aspen, J., Rycroft, J. A., & O'Brien, D. C. (2000). The acute physiological and mood effects of tea and coffee: The role of caffeine level. *Pharmacology, Biochemistry & Behavior*, *66*, 19-28. doi:10.1016/S0091-3057(00)00192-1

Repantis, D., Schlattmann, P., Laisney, O., & Heuser, I. (2010). Modafinil and methylphenidate for neuroenhancement in healthy individuals: A systematic review. *Pharmacological Research*, *62*, 187-206. doi:10.1016/j.phrs.2010.04.002

Restle, F., & Davis, J. H. (1962). Success and speed of problem solving by individuals and groups. *Psychological Review*, *69*, 520-536. doi:10.1037/h0043862

Reyner, L. A., & Horne, J. A. (2013). Sleep restriction and serving accuracy in performance tennis players, and effects of caffeine. *Physiology & Behavior*, *120*, 93-96. doi:10.1016/j.physbeh.2013.07.002

Ringelmann, M. (1913). Recherches sur les moteurs animés: Travail de l'homme [Research on animate sources of power: The work of man]. *Annales de l'Institut National Agronomique*, *12*, 1-40.

Roache, J. D., & Griffiths, R. R. (1987). Interactions of diazepam and caffeine: Behavioral and subjective dose effects in humans. *Pharmacology, Biochemistry & Behavior*, *26*, 801-812. doi:10.1016/0091-3057(87)90614-9

Rogers, P. J., Heatherley, S. V., Mullings, E. L., & Smith, J. E. (2013). Faster but not smarter: Effects of caffeine and caffeine withdrawal on alertness and performance. *Psychopharmacology*, *226*, 229-240. doi:10.1007/s00213-012-2889-4

Rosekind, M. R., Gregory, K. B., Mallis, M. M., Brandt, S. L., Seal, B., & Lerner, D. (2010). The cost of poor sleep: Workplace productivity loss and associated costs. *Journal of Occupational & Environmental Medicine*, *52*, 91-98. doi:10.1097/JOM.0b013e3181c78c30

Sahakian, B. J., Bruhl, A. B., Cook, J., Killikelly, C., Savulich, G., Piercy, T., . . . Jones, P. B. (2015). The impact of neuroscience on society: Cognitive enhancement in neuropsychiatric disorders and in healthy people. *Philosophical Transactions of the Royal Society B*, *370*, 20140214. doi:10.1098/rstb.2014.0214

Santoni de Sio, F., Faber, N. S., Savulescu, J., & Vincent, N. A. (in press). Why less praise for enhanced performance? Moving beyond responsibility-shifting, authenticity, and cheating, towards a nature-of-activities approach. In F. Jotterand & V. Dubljevic (Eds.), *Cognitive enhancement: Ethical and policy implications in international perspectives*. Oxford, UK: Oxford University Press.

Santoni de Sio, F., Faulmüller, N., & Vincent, N. A. (2014). How cognitive enhancement can change our duties. *Frontiers in Systems Neuroscience*, *8*, 131. doi:10.3389/fnsys.2014.00131

Saper, C. B., Scammell, T. E., & Lu, J. (2005). Hypothalamic regulation of sleep and circadian rhythms. *Nature*, *437*, 1257-1263. doi:10.1038/nature04284

Schelle, K. J., Faulmüller, N., Caviola, L., & Hewstone, M. (2014). Attitudes towards pharmacological cognitive enhancement: A review. *Frontiers in Systems Neuroscience*, *8*, 53. doi:10.3389/fnsys.2014.00053

Schermer, M., Bolt, I., De Jongh, R., & Olivier, B. (2009). The future of psychopharmacological enhancements: Expectations and policies. *Neuroethics*, *2*, 75-87. doi:10.1007/s12152-009-9032-1

Schoenborn, C. A., & Adams, P. F. (2010). *Health behaviors of adults: United States, 2005–2007* (Vital and Health Statistics, Vol. 10, Issue No. 245; DHHS Publication No. [PHS] 2010–1573). Washington, DC: National Center for Health Statistics. Retrieved from http://www.cdc.gov/nchs/data/series/sr_10/sr10_245.pdf

Schulz-Hardt, S., & Brodbeck, F. C. (2015). Group performance and leadership. In M. Hewstone, W. Stroebe, & K. Jonas (Eds.), *An introduction to social psychology* (6th ed., pp. 407-438). Chichester, UK: Wiley.

Selye, H. (1936). A syndrome produced by diverse nocuous agents. *Nature*, *138*, 32. doi:10.1038/138032a0

Sharwood, L. N., Elkington, J., Meuleners, L., Ivers, R., Boufous, S., & Stevenson, M. (2013). Use of caffeinated substances and risk of crashes in long distance drivers of commercial vehicles: Case-control study. *British Medical Journal, 346*, Article f1140. doi:10.1136/bmj.f1140

Shaw, M. E. (1932). A comparison of individuals and small groups in the rational solution of complex problems. *American Journal of Psychology*, *44*, 491-504.

Shaw, M. E. (1963). *Scaling group tasks: A method for dimensional analysis* (Tech. Rep. No. 1). Gainesville: University of Florida.

Sicard, B. A., Perault, M. C., Enslen, M., Chauffard, F., Vandel, B., & Tachon, P. (1996). The effects of 600 mg of slow release caffeine on mood and alertness. *Aviation, Space, and Environmental Medicine*, *67*, 859-862.

Singh, I., Bard, I., & Jackson, J. (2014). Robust resilience and substantial interest: A survey of pharmacological cognitive enhancement among university students in the UK and Ireland. *PLoS ONE*, *9*, e105969. doi:10.1371/journal.pone.0105969

Smeets, T., Dziobek, I., & Wolf, O. T. (2009). Social cognition under stress: Differential effects of stress-induced cortisol elevations in healthy young men and women. *Hormones and Behavior*, *55*, 507-513. doi:10.1016/j.yhbeh.2009.01.011

Smith, A. P. (1994). Caffeine, performance, mood and status of reduced alertness. *Pharmacopsychoecologia*, *7*, 75-86.

Smith, A. P. (2002). Effects of caffeine on human behavior. *Food & Chemical Toxicology*, *40*, 1243-1255. doi:10.1016/S0278-6915(02)00096-0

Smith, A. P., Kendrick, A. M., & Maben, A. L. (1992). Effects of breakfast and caffeine on performance and mood in the late morning and after lunch. *Neuropsychobiology*, *26*, 198-204. doi:10.1159/000118920

Smith, B. D., Osborne, A., Mann, M., Jones, H., & White, T. (2004). Arousal and behavior: Biopsychological effects of caffeine. In A. Nehlig (Ed.), *Coffee, tea, chocolate, and the brain* (pp. 35-53). New York, NY: Taylor & Francis. doi:10.1201/9780203618851

Smith, M. E., & Farah, M. J. (2011). Are prescription stimulants "smart pills"? The epidemiology and cognitive neuroscience of prescription stimulant use by normal healthy individuals. *Psychological Bulletin*, *137*, 717-741. doi:10.1037/a0023825

Smith, M. E., McEvoy, L. K., & Gevins, A. (2002). The impact of moderate sleep loss on neurophysiologic signals during working-memory task performance. *Sleep*, *25*, 784-794.

Starcke, K., & Brand, M. (2012). Decision making under stress: A selective review. *Neuroscience and Biobehavioral Reviews*, *36*, 1228-1248. doi:10.1016/j.neubiorev.2012.02.003

Stasser, G., & Titus, W. (1985). Pooling of unshared information in group decision making: Biased information sampling during discussion. *Journal of Personality and Social Psychology*, *48*, 1467-1478. doi:10.1037/0022-3514.48.6.1467

Steiner, I. D. (1966). Models for inferring relationships between group size and potential group productivity. *Systems Research*, *11*, 273-283. doi:10.1002/bs.3830110404

Steiner, I. D. (1972). *Group process and productivity*. New York, NY: Academic Press.

Streufert, S., Satish, U., Pogash, R., Gingrich, D., Landis, R., Roache, J., & Severs, W. (1997). Excess coffee consumption in simulated complex work settings: Detriment or facilitation of performance? *Journal of Applied Psychology*, *82*, 774-782. doi:10.1037/0021-9010.82.5.774

Stroebe, W., & Diehl, M. (1994). Why groups are less effective than their members: On productivity losses in idea-generating groups. In W. Stroebe & M. Hewstone (Eds.), *European review of social psychology* (Vol. 5, pp. 271-303). London, England: Wiley.

Surowiecki, J. (2004). *The wisdom of crowds: Why the many are smarter than the few and how collective wisdom shapes business, economies, societies, and nations*. New York, NY: Anchor.

Swezey, R. W., & Salas, E. (1992). *Teams: Their training and performance*. Norwood, NJ: Ablex.

Takahashi, T., Ikeda, K., Ishikawa, M., Tsukasaki, T., Nakama, D., Tanida, S., & Kameda, T. (2004). Social stress-induced cortisol elevation acutely impairs social memory in humans. *Neuroscience Letters*, *363*, 125-130. doi:10.1016/j.neulet.2004.03.062

Tavakoli, P., Muller-Gass, A., & Campbell, K. (2015). Partial sleep deprivation does not alter processes involved in semantic word priming: Event-related potential evidence. *Brain and Cognition*, *94*, 17-23. doi:10.1016/j.bandc.2014.12.003

Tempesta, D., Couyoumdjian, A., Curcio, G., Moroni, F., Marzano, C., De Gennaro, L., & Ferrara, M. (2010). Lack of sleep affects the evaluation of emotional stimuli. *Brain Research Bulletin*, *29*, 104-108. doi:10.1016/j.brainresbull.2010.01.014

Tieges, Z., Ridderinkhof, K., Snel, J., & Kok, A. (2004). Caffeine strengthens action monitoring: Evidence from the error-related negativity. *Cognitive Brain Research*, *21*, 87-93. doi:10.1016/j.cogbrainres.2004.06.001

Tomova, L., von Dawans, B., Heinrichs, M., Silani, G., & Lamm, C. (2014). Is stress affecting our ability to tune into others? Evidence for gender differences in the effects of stress on self-other distinction. *Psychoneuroendocrinology*, *43*, 95-104. doi:10.1016/j.psyneuen.2014.02.006

Turner, D. C., Robbins, T. W., Clark, L., Aron, A. R., Dowson, J., & Sahakian, B. J. (2003). Cognitive enhancing effects of modafinil in healthy volunteers. *Psychopharmacology*, *165*, 260-269. doi:10.1007/s00213-002-1250-8

Turner, J. C., Oakes, P. J., Haslam, S. A., & McGarty, C. (1994). Self and collective: Cognition and social context. *Personality and Social Psychology Bulletin*, *20*, 454-463. doi:10.1177/0146167294205002

van Knippenberg, D., & Schippers, M. C. (2007). Work group diversity. *Annual Review of Psychology*, *58*, 515-541. doi:10.1146/annurev.psych.58.110405.085546

Vincent, G., Ferguson, S. A., Tran, J., Larsen, B., Wolkow, A., & Aisbett, B. (2015). Sleep restriction during simulated wildfire suppression: Effect on physical task performance. *PLoS ONE*, *10*(1), e0115329. doi:10.1371/journal.pone.0115329

Wagner, D. T., Barnes, C. M., Lim, V. K., & Ferris, D. L. (2012). Lost sleep and cyberloafing: Evidence from the laboratory and a daylight saving time quasi-experiment. *Journal of Applied Psychology*, *97*, 1068-1076. doi:10.1037/a0027557

Warburton, D. M. (1995). Effects of caffeine on cognition and mood without caffeine abstinence. *Psychopharmacology*, *119*, 66-70. doi:10.1007/BF02246055

Wardle, M. C., Treadway, L. M., Mayo, D. H., Zald, D. H., & de Wit, H. (2011). Amping up effort: Effects of d-amphetamine on human effort-based decision-making. *The Journal of Neuroscience*, *31*, 16597-16602. doi:10.1523/JNEUROSCI.4387-11.2011

Welsh, D. T., Ellis, A. P. J., Christian, M. S., & Mai, K. M. (2014). Building a self-regulatory model of sleep deprivation and deception: The role of caffeine and social influence. *Journal of Applied Psychology*, *99*, 1268-1277. doi:10.1037/a0036202

Williams, K. D., & Karau, S. J. (1991). Social loafing and social compensation: The effects of expectations of co-worker performance. *Journal of Personality and Social Psychology*, *61*, 570-581. doi:10.1037/0022-3514.61.4.570

Williamson, A. M., & Feyer, A. M. (2000). Moderate sleep deprivation produces impairments in cognitive and motor performance equivalent to legally prescribed levels of alcohol intoxication. *Occupational & Environmental Medicine*, *57*, 649-655. doi:10.1136/oem.57.10.649

Wolf, O. T. (2009). Stress and memory in humans: Twelve years of progress? *Brain Research*, *1293*, 142-154. doi:10.1016/j.brainres.2009.04.013

Wölfer, R., Faber, N. S., & Hewstone, M. (2015). Social network analysis in the science of groups. *Group Dynamics: Theory, Research, and Practice*, *19*, 45-61. doi:10.1037/gdn0000021

Xie, L., Kang, H., Xu, Q., Chen, M. J., Liao, Y., Thiyagarajan, M., . . . Nedergaard, M. (2013). Sleep drives metabolite clearance from the adult brain. *Science*, *344*, 373-377. doi:10.1126/science.1241224

Yang, G., Lai, C. S. W., Cichon, J., Ma, L., Li, W., & Gan, W. B. (2014). Sleep promotes branch-specific formation of dendritic spines after learning. *Science*, *344*, 1173-1178. doi:10.1126/science.1249098

Yoo, S., Gujar, N., Hu, P. T., Jolesz, F. A., & Walker, M. P. (2007). The human brain without sleep—A prefrontal amygdala disconnect. *Current Biology*, *17*, R877-R878. doi:10.1016/j.cub.2007.08.007

Ziegler, R., Diehl, M., & Zijlstra, G. (2000). Idea production in nominal and virtual groups: Does computer-mediated communication improve group brainstorming? *Group Processes and Intergroup Relations*, *3*, 141-158. doi:10.1177/136843020003200