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On the Boundary Conditions of Effort Losses and Effort Gains in Action Teams

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While people's willingness to work hard can be reduced in teams (i.e., effort losses in teams as compared with individual work), it is less recognized that teamwork can also stimulate additional efforts (i.e., effort gains). Building on and extending existing theory, we (a) suggest an integration of these two research streams, and (b) provide evidence for team-related effort gains in action teams. In a first study, we tested our predictions by reanalyzing a field data set of 302,576 swimming performances in individual and relay races (Neugart & Richiardi, 2013). Consistent with our hypotheses, we observed a linear increase in effort across the relay. The first relay swimmers showed effort losses in the relay as compared with the individual competition whereas the remaining relay swimmers showed effort gains. However, this was only evident (a) when team members could realistically expect meaningful team outcomes in return for their performance, and (b) when the valence of these outcomes was equivalent to individual competitions. If such favorable conditions were not given, we found effort losses in team as compared with individual competitions at all relay positions. Results of a second study ($N = 228$) showed that the linear increase in effort across the relay was indeed attributable to the team members' serial position and not to their relative strength. Together, the studies demonstrate the motivating potential of teamwork even in the high performance contexts of action teams, such as competitive sports relays, where athletes are already highly motivated in their individual competitions.

Keywords: Collective Effort Model, effort gains, effort losses, motivation, teamwork

Most people experience both strongly demotivating as well as highly motivating episodes in teams. These Janus-faced lay experiences are, however, not fully reflected in the research literature. Whereas effort losses in teams (i.e., reduced effort during teamwork as compared with individual work; e.g., Karau & Williams, 1993)[1] represent a widely accepted finding across scientific disciplines, the possibility that teamwork can result in effort gains (i.e., higher effort during teamwork as compared with individual work; e.g., Kerr & Hertel, 2011) is less acknowledged and sometimes even neglected (e.g., Kidwell & Bennett, 1993; Steiner, 1972). In recent years, scholars have begun to document effort gains in teams. However, this research is still only loosely connected with traditional work on effort losses in teams (for exceptions, see, e.g., Lount & Wilk, 2014; Williams & Karau, 1991). As an initial approach to integrate theory on effort losses and gains in teams, Karau, Markus, and Williams (2000) advanced the Collective Effort Model (CEM, Karau & Williams, 1993) and put forth hypotheses that specified when people would exert less or more effort in teamwork compared with individual work. To date, however, these hypotheses are still awaiting empirical testing.

In this research, we empirically determined boundary conditions under which teamwork demotivates and motivates team members, as hypothesized by the CEM (Karau et al., 2000). In doing so, we focused on *action teams* as a specific type of professional teams (Sundstrom, 1999; Sundstrom, DeMeuse, & Futrell, 1990), which is becoming increasingly prevalent in today's working world.

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[1] Prior research termed these findings "motivation losses" rather than "effort losses". We prefer the term "effort" because it reflects the intensity and persistence of behavior that are usually studied in pertinent studies. Motivation is the broader term and additionally encompasses the direction of behavior (Campbell, 1990; Geen, 1995), which is typically not investigated in these kinds of studies (cf. Karau & Williams, 1993; Kerr & Hertel, 2011).

Sundstrom (1999, p. 20) defines action teams as follows: "Teams in the category of action [. . .] conduct complex, time-limited engagements with audiences, adversaries, or challenging environments in 'performance events'." Action teams are, for example, fire crews, military units, political campaign teams, negotiation teams, surgical units, musical ensembles, or theater troupes (Ishak & Ballard, 2012). Competitive teams in professional sports are another example of action teams. In this research, we focus on this type of action teams. Notably, competitive sports teams provide an excellent field for empirical examinations of motivating effects of teamwork due to the existence of comparable individual performance settings (e.g., individual running or swimming competitions). At the same time, however, competitive sports teams provide a particularly challenging context for detecting motivating effects of teamwork given that the level of effort is generally already very high in individual competitions.

The work of action teams and sports teams in particular consists of relatively brief performance events. These events require *maximum performance* (i.e., what people can do at their very best as opposed to how well people typically do; cf. Sackett, Zedeck, & Fogli, 1988). This is because work in action teams is characterized by a high degree of *finality* (i.e., work cannot be redone at a later point of time and the provided performance is irreversible) and by goals that either imply to strive for perfection in performance or to outperform one's adversaries (see Ishak & Ballard, 2012).

In the context of sequentially working sports teams, both effort losses and gains in teams have already been reported in the literature. In their analysis of swimming data collected on athletes who swam in both the individual and relay competitions of the same sports events, Neugart and Richiardi (2013) reported overall *effort losses* for swimmers in relay races as compared with their individual races, and these effort losses seemed to decrease across successive positions in the relay. By contrast, Hüffmeier and colleagues (e.g., Hüffmeier & Hertel, 2011; Hüffmeier, Krumm, Kanthak, & Hertel, 2012) revealed *effort gains* in swimming relays as compared with their individual races under certain conditions. However, both types of findings were tainted by some methodological issues (for details, see below) that precluded clear conclusions on the respective boundary conditions.

In this research, we empirically examined predictions derived from the CEM in the context of sequentially working sports teams. Moreover, we further specified the CEM and tested two alternative explanations of effort gains in sequential teamwork. The *relative strength* explanation (cf. Osborn, Irwin, Skogsberg, & Feltz, 2012) suggests that differences in team members' abilities are decisive for effort gains to emerge. According to this explanation, weaker members of a relay should show effort gains in teams because they should feel obliged not to let their team down (e.g., Hertel, Kerr, & Messé, 2000). This effect should be the more pronounced the weaker a team member is as compared with her/his fellow team members. By contrast, the *serial position hypothesis* (cf. Au, Chen, & Komorita, 1998; Hüffmeier & Hertel, 2011; Hüffmeier et al., 2012) suggests that the order in which team members work is decisive for effort gains to emerge. Team members working at later positions are expected to experience higher responsibility for the final team results because fewer chances exist that a poor performance can be compensated by following team partners.

Thus, our research offers the following novel contributions to the literature on teamwork: (a) We conducted (to our knowledge) the first empirical test of assumed boundary conditions that can be used to delineate when effort losses and gains in teams occur (cf. Karau et al., 2000). Concomitantly, we resolve the existing inconsistency regarding whether and under which conditions sequential teamwork results in effort *losses* (cf. Neugart & Richiardi, 2013) or effort *gains* (cf. Hüffmeier et al., 2012). (b) We tested motivating effects of teamwork analyzing a large archival data set from a high-stakes environment, that is, swimming performances from various prestigious championships. Such championships represent a particularly conservative context for the detection of motivating effects of teamwork because athletes are already performing at very high levels during individual competitions. Specifically, we compared the performances of professional swimmers in relay races with their performances in individual races to gather evidence for effort gains (and losses) in teams in field settings. (c) We compared two factors potentially responsible for effort gains in sequential teamwork, team members' relative strength (Osborn et al., 2012) or serial position (Au et al., 1998; Hüffmeier & Hertel, 2011). This comparison extends the CEM, which is silent on specific antecedents that may trigger the critical perceptions that determine team members' effort levels. From an applied perspective, we provide insights into how different contextual conditions can lead to effort losses in teams and how they may be modified to result in effort gains.

Predicting Individuals' Effort in Teams

The Collective Effort Model (CEM; Karau & Williams, 1993) originally focused almost exclusively on the emergence of effort losses in teams. It describes three components that determine members' effort during teamwork: *expectancy* (i.e., the perceived extent to which individual effort is related to individual performance), *instrumentality* (i.e., "the degree to which high-quality performance is perceived as instrumental in obtaining an outcome," Karau & Williams, 1993, p. 685), and *valence* (i.e., the perceived importance, relevance, or meaningfulness of that outcome; cf. Karau & Williams, 1997). In accordance with the additional complexities involved in teamwork as compared with individual work, the CEM splits the instrumentality component into three contingencies. Members thus perceive their own contribution to the team's accomplishments as instrumental to the extent that they perceive contingencies between (a) their individual performance and the team's performance, (b) the team's performance and the resulting team outcomes, and (c) the team's outcomes and the outcomes they individually receive. Generally, the CEM predicts that the impact of team- versus individual work on an individual's effort is moderated by the strength of these five components (expectancy, three instrumentality contingencies, and valence).

In a later advancement of the CEM, Karau et al. (2000) extended their model and proposed testable hypotheses on the boundary conditions of *effort gains* during teamwork. Specifically, concerning valence, they predicted that effort gains in teams are likely when "[. . .] the outcomes associated with group performance are perceived as valuable—preferably as equal to or superior to those associated with mere individual performance" (Karau et al., 2000, p. 182). Integrating the prior assumptions of the CEM with this *valence hypothesis*, our key assumption is that effort gains during team- as compared with individual work emerge when the following conditions are met: Team members (a) perceive their individual contributions to the team performance as critical (first instrumentality contingency), (b) see a strong relation between team performance and team outcomes (second instrumentality contingency), and (c) value team outcomes (valence) to an extent at least comparable to outcomes of individual work.

Existing Research on Sequential Teamwork in Field Settings

Neugart and Richiardi (2013) analyzed a large-scale data set consisting of more than 300,000 observations of swimmers who competed between 1972 and 2009. These swimmers took part in the individual and relay competitions involving the same stroke at the same event. Overall, the authors reported *effort losses* in the relays in comparison with the individual competitions, Moreover, these effort losses were found to decrease across the consecutive positions: Whereas the starting relay swimmers showed the most pronounced effort losses as compared with the individual competitions (i.e., they swam particularly slower in the relay than in the individual competition), these losses became smaller for swimmers in the second and third starting positions, and vanished at the fourth position. The authors also reported a number of moderation analyses and draw the conclusion that—across the tested variables—their results "still hold" (p. 198) or, in other words, were largely unmoderated.

In the present article, we argue that this conclusion is not warranted. Specifically, the explicit assumption of equivalent outcome valence in individual and team work by Neugart and Richiardi (2013) prevents clear conclusions: Despite analyzing heterogeneous data that comprised local, national, and international championships, Neugart and Richiardi assumed "that the relay and the individual competition have the same structure of incentives and costs" (p. 192). However, the reward structures—and thus the valence—for individual competitions and relays can differ considerably across swimming events. For instance, in international events such as the Olympics or World Championships, the ultimate goal in both the individual and the relay competition is to win a medal. By contrast, the ultimate goal in national sports events is to qualify for the international events. However, this only holds for the winners of the individual competitions in national sports events, not for the winners of the relay competitions because relays at international events typically consist of the best four national swimmers and not of the best relay from the national event.[2] Thus, in national sports events, the valence of relay results is considerably lower than the valence of the results of individual competitions. To achieve a precise conception of an individual member's effort in the relays, this central difference should be explicitly included in the analyses.

In contrast to Neugart and Richiardi's (2013) rather pessimistic conclusions, Hüffmeier and colleagues (e.g., Hüffmeier & Hertel, 2011; Hüffmeier et al., 2012) documented evidence for effort *gains* in swimming relay competitions. Notably, they analyzed conditions where individual and teamwork competitions were equivalent in valence (i.e., the individual and relay freestyle competitions at *international* events such as the Olympics, World and European Championships). Based on the assumption that the perceived instrumentality of individual contributions for the team outcome (also termed "criticality" or "social indispensability") increases with the serial position in a sequentially working team (successfully tested in a pilot study; see Hüffmeier & Hertel, 2011), Hüffmeier and colleagues hypothesized and found *effort gains* in the relay teams. Whereas swimming times of the starting swimmers during the relay races were comparable to their swimming times in the individual competitions, the swimmers in the other positions were faster in the relay as compared with their individual competitions. These effort gains were most pronounced for the last swimmers—who should have perceived the highest instrumentality of their efforts for the team outcome.

However, two limitations should be noted in the work by Hüffmeier and colleagues. First, the sample sizes were rather small (e.g., only 12 swimmers at relay Position 3; see Hüffmeier et al., 2012). Current sampling standards (e.g., Simmons, Nelson, & Simonsohn, 2011) recommend a minimum of 20 observations per condition (i.e., relay position in this research). Second, Hüffmeier and colleagues focused on detecting effort gains in teams and therefore did not include conditions that made the emergence of effort losses likely (e.g., team competitions with low valence). Taking these limitations into account, the present research reexamined whether and when performance data from swimming relays reflect evidence for effort losses versus gains in teams, using a larger sample for each relay position and modeling boundary conditions that should enable either effort gains or losses.

The Present Research

Based on the *serial position hypothesis* (Au et al., 1998; Hüffmeier & Hertel, 2011), we expected that the perceived contingency between individual members' contributions and team performance (first instrumentality contingency) varies systematically across a team that works sequentially: When working in the beginning of a cycle, poor individual performance (due to fatigue, demotivation, or even errors) can be compensated by persons working later in the performance cycle. However, when working at the end of a cycle, poor individual performance cannot be compensated by others. As a consequence, team members working early in the cycle should perceive a weaker contingency between their individual contributions and the resulting team performance as compared with members working later in the cycle. Indeed, perceived indispensability (i.e., high instrumentality) of persons' individual contribution has been shown to increase with serial position in sequential teamwork (Au et al., 1998; Hüffmeier & Hertel, 2011; see also Wittchen, Schlereth, & Hertel, 2007). Perceived indispensability for the team performance, in turn, has been found to be a driver of effort gains in teams (Kerr & Hertel, 2011; Weber & Hertel, 2007) and was also expected to underlie effort gains in teams in this research. Thus, individuals' effort during teamwork as compared with individual work should increase with their serial position in sequential teamwork, and, hence, should

[2] In fact, U.S.A. Swimming (i.e., the organization that is responsible for professional swimmers in the United States), for instance, does not even consider relay performances as a relevant criterion for selecting swimmers for major swimming events such as the Olympics.

exceed the effort level shown during individual work for the final positions of sequential teamwork.[3]

We further expected that the perceived contingency between a team's performance and its subsequent achievements (second instrumentality contingency) varies systematically between teams. In teams that can reasonably expect to obtain high achievements as a result of their performance (e.g., a medal for swimming relays), the contingency between team performance and team achievements should be perceived as stronger as compared with teams with less positive perspectives (see Karau & Williams, 1993, 2001). We thus expected that for effort gains in teams to emerge, individuals need to perceive that their team has a realistic chance to obtain high team achievements (Hüffmeier et al., 2012).

As a final determinant for effort gains to emerge in teams, we hypothesized that team members must see the team achievements as personally meaningful (i.e., a high, positive outcome valence). If the achievements resulting from team performance are perceived as less meaningful than those resulting from individual performances, effort losses during team as compared with individual work should be more likely than effort gains (i.e., low valence; see also the valence hypothesis as put forth in Karau et al., 2000, and Footnote 2).

In sum, we expected the following three-way interaction: Effort gains in sequential teamwork as compared with individual work should occur when individuals simultaneously perceive (a) their individual contributions as strongly related to the team's performance, (b) the team's performance to be strongly related to the team's outcomes, and (c) a high and positive valence for team outcomes. In other words, reflecting the expected increase in perceived indispensability across sequentially working teams, we predicted a linear increase of teamwork-related effort across the serial positions under these favorable conditions. If any of these preconditions is not met, however, effort losses should result in comparison with individual work.[4]

Procedure of Study 1

For Study 1, we used the data reported by Neugart and Richiardi (2013) which the authors made available as an Appendix to their manuscript on the journal's homepage (*European Economic Review*).[5] We reanalyzed the data by applying the following steps: First, we reproduced the results reported by Neugart and Richiardi (2013). Ensuring data reproducibility (see Asendorpf et al., 2013) is not trivial because different researchers might come to different conclusions when analyzing the same data set (Silberzahn et al., 2015). Second, in a pilot study (see below) we empirically addressed Neugart and Richiardi's (2013) *assumption* that there is a certain reaction time (RT) advantage in the relay in comparison with the individual competition that does not differ between relay positions (see Neugart & Richiardi, 2013, p. 192). Based on this assumption, the authors interpreted observed performance gains in a relay below this assumed threshold as effort losses. However, RTs are officially recorded for various swimming events and are publicly reported (e.g., at http://www.swimrankings.net/). Thus, instead of assuming a general RT advantage in the relay competition, we estimated this RT advantage for each relay position based on available empirical evidence. Therefore, we conducted a pilot study to obtain an empirical estimate of the RT advantage in relay competitions in comparison with individual competitions, separately for each relay position and with data stratified by swimming distance, position in the relay, gender, and type of swimming events. We then used the empirical estimates to correct for the RT advantage of the relay competition separately for each relay position using the data reported by Neugart and Richiardi (2013). Finally, we tested our main hypothesis based on these corrected data.

Pilot Study: Obtaining Empirical Reaction Time Estimates

The official swimming rules according to the world swimming federation (FINA)[6] prescribe different starting procedures for individual competitions (a "gun start") versus relay competitions (a "flying start").[7] These different starting procedures constitute the basis of the RT advantage of a relay versus an individual competition (occurring for swimmers in Positions 2 to 4). In contrast to Neugart and Richiardi (2013), who estimated this advantage to be 0.6 s on the basis of discussion contributions in an Online Sports forum (U.S. Master Swimming discussion forum), we conducted a pilot study to obtain empirical estimates for each relay position.

We obtained RT data from four pertinent web platforms (omegatiming.com; http://www.swimrankings.net/; swimmingworldmagazine.com; swimming.org.au). For the data collection process, we used the following restrictions: First, we collected data from 100 m and 200 m freestyle competitions. The majority of the competitions (about 70%) in Neugart and Richiardi's (2013) data set were freestyle competitions. Moreover, the 100 m and 200 m swimming distances are the most prevalent competitions with RT data provided in online databases. Second, we collected a comparable amount of data for both genders. Third, to avoid confounds between the RT data and specific relay positions or specific swimming events, we always collected full data sets from a specific sports event (e.g., RT

[3] Please note that conditions for social comparison or social facilitation as other potential drivers of effort gains in teams are comparable between the positions in sequential teamwork.

[4] In addition to the three potential moderators considered so far, we presupposed that the remaining two potential moderators outlined in the CEM (Karau & Williams, 1993) will be given (i.e., they will not be perceived as low) and will be stable in the context of our study. Specifically, a positive expectancy should exist because our sample consisted of trained athletes sufficiently capable of performing the task (i.e., swimming in a competition). The third contingency of the instrumentality process (i.e., the relation between team and individual outcomes) should also be perceived as high by all participants given that all relay members receive the same medal and usually equivalent financial compensation when a relay finishes in the medal ranks. For relays not finishing in the medal ranks, none of the members would receive a medal and, in most cases, none would receive a financial bonus either.

[5] See http://www.sciencedirect.com/science/article/pii/S0014292113000925.

[6] We used the FINA homepage as the source for the official swimming rules (http://www.fina.org/content/fina-rules)

[7] Swimmers in individual competitions and the first swimmers in a relay are not allowed to move on their starting blocks until an acoustic signal sounds. Thus, they are not allowed to leave their stationary position prior to the starting signal. This signal cannot be reliably anticipated. Relay swimmers in Positions 2 to 4, by contrast, can reliably anticipate their "starting signal", which is the moment when the incoming swimmer touches the wall of the swimming pool. Moreover, swimmers in Positions 2 to 4 are also allowed to move before the incoming swimmer touches the wall if at least one foot still stays on the block.

data for four female swimmers swimming at the four different relay positions from the individual and relay competitions at this specific sports event), and collected data from different events and different years.[8]

Our pilot study sample comprised 240 swimmers who participated in swimming events from 1998 (about the time when the official documentation of RT data had begun) to 2009 (the year of the most recent data included by Neugart & Richiardi, 2013; for details see Table 1). To obtain estimates of the potential advantage in RTs in the relay competition, we subtracted each swimmer's RT in the relay competition from his or her RT in the individual competition.

A 4 (relay position: first vs. second vs. third vs. fourth) × 2 (gender: female vs. male) × 2 (swimming distance: 100 m vs. 200 m) ANOVA on this RT difference score revealed a main effect of relay position, $F(3, 223) = 162.19$, $p < .001$, whereas all other main and interactions effects were not significant, all Fs < 1.7, all ps $> .196$. The main effect of relay position was expected because the starting procedure for the individual competition and the first relay position differ from the starting procedure for relay Positions 2 to 4 ("flying start"). We obtained RT estimates of about 0 s for relay Position 1 and about 0.5 s for the three ensuing relay positions (see Table 2 for details). Thus, the empirically derived RT advantage for Positions 2 to 4 in a swimming relay was somewhat smaller than the expert estimate used by Neugart and Richiardi (2013). Based on our empirical results (see Table 2), we corrected the dependent variable in Study 1 to account for differences in starting procedures in individual versus relay competitions (separately for women, men, relay positions, and swimming distances).

Table 1
Samples Sizes as a Function of Gender, Serial Position, and Swimming Distance (Pilot Study)

		Swimming distance	
Gender	Serial position	100 m	200 m
Female	1	$N = 15$	$N = 14$
	2	$N = 15$	$N = 14$
	3	$N = 15$	$N = 14$
	4	$N = 15$	$N = 14$
Male	1	$N = 14$	$N = 17$
	2	$N = 14$	$N = 17$
	3	$N = 14$	$N = 17$
	4	$N = 14$	$N = 17$

Table 2
Reaction Time Differences Between the Individual and Relay Competitions (Individual Minus Relay Reaction Time) as a Function of Gender, Serial Position, and Swimming Distance (Pilot Study)

		Swimming distance	
Gender	Serial position	100 m	200 m
Female	1	−0.012 (0.02)	−0.011 (0.03)
	2	0.422 (0.32)	0.476 (0.15)
	3	0.486 (0.13)	0.521 (0.13)
	4	0.452 (0.27)	0.489 (0.09)
Male	1	0.019 (0.05)	0.001 (0.03)
	2	0.505 (0.12)	0.488 (0.14)
	3	0.455 (0.17)	0.506 (0.11)
	4	0.524 (0.15)	0.523 (0.10)

Note. Reaction time differences are given in seconds. Numbers in parentheses denote standard deviations.

Study 1

Method

Sample. Neugart and Richiardi's (2013) original data as documented on the journal homepage was provided by the Swiss Company GeoLogix AG and comprised exactly "302,576 observations of performances of individual swimmers at about 7,000 events which took place worldwide between 1972 and 2009" (Neugart & Richiardi, 2013, p. 190). All observations consisted of the performances of one athlete in (a) the individual competition and (b) the relay competition of the same sports event swimming the same distance (e.g., 100 m) with the same stroke (e.g., freestyle). Sample sizes for the starting positions of the relay varied from 64,481 observations (for Position 1) to 86,841 observations (for Position 2). The order of the competitions differed substantially: For about 26% of the observations, the individual competition took place one day before the relay competition; for about 27% of the observations, the order was reversed; and for the rest of the data, both events occurred on the same day with no further information about the exact order at that specific day. The sports events ranged from the most important international championships (Olympics, World Championships, etc.) to national and even local championships. National championships were by far the most frequent type of event in the sample (about 95%). About 70% of the competitions were freestyle competitions. The data comprised swimmers with 142 different nationalities, who were on average about 18 years old ($M_{age} = 17.8$). About half of the swimmers were female (50.34%). More details can be found at Neugart and Richiardi (2013).

Procedure. To operationalize the three factors included in our hypothesized three-way interaction, we took the following measures: First, we used the positions in the relay to operationalize the first contingency of the instrumentality process (i.e., the perceived relation between individuals' contribution and team performance; see Karau & Williams, 1993). This approach corresponds with prior research revealing that social indispensability perceptions increase over the course of the relay (Hüffmeier & Hertel, 2011).

Second, we used the relay team's final placement as the operationalization of the second contingency of the instrumentality process (i.e., the perceived relation between the team's perfor-

[8] Reaction time data from important sports events (e.g., Olympics, World and European Championships) is systematically limited. In these events, only the two best swimmers from a country are allowed to swim in the individual competitions. These swimmers are typically assigned to Positions 1 and 4 in their relays. It would thus have been possible, for instance, to collect large samples for these two relay positions, whereas comparable sample sizes for Positions 2 and 3 were not available. At the same time, however, such estimates—based on large versus small subsamples—would inevitably have been confounded with the swimmers' ability. Therefore, it appeared reasonable to collect a stratified sample with comparable sample sizes across relay positions, a practice that allowed us to avoid such confounds.

mance and the team's outcomes). Relays in first to fourth place were assigned to the *high expectations for the team's outcomes condition*, whereas relays in fifth place or worse were assigned to the *low expectations for the team's outcomes condition*. This approach was chosen because a team member's perception that the team might receive tangible (e.g., medal, monetary prize, etc.) and/or intangible outcomes (e.g., praise, social cohesion, etc.) should be stronger for swimmers who had a realistic chance to win a medal than for those who did not (see also Hüffmeier et al., 2012). Note that although we made the relevant decisions on the basis of the final data (i.e., post hoc), these perceptions most likely emerged for the athletes before or, at the latest, during the races. In fact, a relay's performance level is typically known before the race (e.g., based on swimming times from qualifiers or prelims) or after the first swimmers in a relay are finished.[9]

Third, we assigned all observations from the Olympic Games, World Championships, European Championships, Pan Pacific Games, Commonwealth Games, and Universiades to the *high valence condition*. This approach appears adequate and rather conservative. In such international competitions, the perceived valence of both the relay and the individual competitions should be high (and equivalent) because the ultimate goal in both competitions is to win a medal. By contrast, observations from national or local championships were assigned to the *low valence condition*. In fact, the perceived valence of national relay competitions should be systematically lower than that of individual competitions because relay swimmers have a much less attractive ultimate goal (i.e., "only" win vs. win *and* qualify for upcoming international championships; see also Footnote 2).

As dependent variable, we used the difference between each swimmer's individual and relay performances (corrected by the estimated RT advantage according to her/his relay position) as an indicator of her/his effort during the relay in comparison with her/his effort during the individual competition (see Footnote 11, for a discussion of difference scores as dependent variables). Specifically, we subtracted each swimmer's relay time from her/his time during the individual competition. Thus, positive values of the dependent variable emerge if swimmers swam faster (i.e., needed less time) in the relay than in the individual competition (effort gains in teams); negative values result if swimmers swam slower (i.e., needed more time) in the relay than in the individual competition (effort losses in teams).

Results

Preliminary analyses. First, we obtained the same results as reported by Neugart and Richiardi (2013) when conducting the analyses described by these authors, demonstrating data reproducibility. We then corrected the swimming times in the data set by applying the estimates based on the empirical data obtained in our pilot study (i.e., we added the RT difference to the relay swimming times).

Hypothesis test. Levene's test for homogeneity of variances yielded a significant result, $F(31, 302544) = 100.81$, $p < .001$. However, in light of the substantial number of cases in all cells, we considered the subsequent results to be robust (cf. Tabachnick & Fidell, 2013).

The 4 (serial position) × 2 (expected team outcomes) × 2 (valence) × 2 (gender) ANOVA revealed significant main effects of serial position, $F(3, 302544) = 51.96$, $p < .001$, partial $\eta^2 = .001$, expected team outcomes, $F(1, 302544) = 60.31$, $p < .001$, partial $\eta^2 < .001$, and valence, $F(1, 302544) = 272.43$, $p < .001$, partial $\eta^2 = .001$, but not gender, $F(1, 302544) = 1.62$, $p = .204$, partial $\eta^2 < .001$. Although the interaction of all four factors was not significant, $F(3, 302544) = 0.34$, $p = .797$, partial $\eta^2 < .001$, the predicted three-way interaction yielded a significant result, $F(3, 302544) = 8.04$, $p < .001$, partial $\eta^2 < .001$, providing first support for Hypothesis 1.[10] Please note that very small effect sizes may nevertheless be meaningful in swimming events, where fractions of seconds can be decisive for winning or losing a medal. To illustrate the magnitude and practical relevance of the results, Table 3 presents average differences between the relay and individual competition swimming times (with positive values indicating effort gains in the relays) separately for each category of the three-way interaction (Serial Position × Expected Team Outcomes × Valence). Whereas low-valence competitions entail effort losses in relays regardless of position or expected team outcomes, a more differentiated picture emerged for high-valence competitions.

To decompose this differentiated pattern, we tested planned contrasts (cf. Rosenthal & Rosnow, 1985) with data from the high-valence conditions only. The first contrast tested the effect of serial position within the high expectations for the team's outcomes condition. To this end, the following contrast coefficients were used: first swimmer in the high-expectations condition [−3], second swimmer in the high-expectations condition [−1], third swimmer in the high-expectations condition [1], fourth swimmer in the high-expectations condition [3], first swimmer in the low-expectations condition [0], second swimmer in the low-expectations condition [0], third swimmer in the low-expectations condition [0], fourth swimmer in the low-expectations condition [0]. This contrast yielded a significant result, $t(467.92) = 6.82$, $p < .001$, with an effect size of Hedges' $g = 1.59$ (see Figure 1). Next, we reversed the contrast coefficients to test the effect of serial order in the low-expectations condition. This second contrast also yielded a significant result, $t(1194.82) = -2.10$, $p < .05$; however, the size of the effect was much smaller, $g = 0.40$ (see Figure 2). This pattern—in particular the clear increase in effort across the relay in the high-valence, high-expectations condition—represents the second piece of empirical support for Hypothesis 1.

[9] Obviously, a better basis for the assignment of relay teams to the high and low expectation conditions would be based on the respective data (swimming times from prior qualifiers or prelims). Unfortunately, these data were not available.

[10] To control whether results remained stable when considering competition order, we conducted an ANOVA with competition order as a covariate. For this analysis, we excluded all cases with unclear competition order. Similar to the results of our main analysis (see below), we found the predicted three-way interaction of serial position, expected team outcomes, and valence, $F(3, 161202) = 5.98$, $p < .001$, partial $\eta^2 < .001$. It should be noted, however, that competition order had a significant overall effect on the dependent variable, $F(1, 161171) = 31.61$, $p < .001$, partial $\eta^2 < .001$, when entered as another factor in our main analysis, that is, in a 4 (serial position) × 2 (expected team outcomes) × 2 (valence) × 2 (gender) × 2 (competition order) ANOVA. Nevertheless, the relevant three-way interaction of serial position, expected team outcomes, and valence was not significantly moderated by competition order, $F(3, 161171) = 2.30$, $p = .075$, partial $\eta^2 < .001$.

Table 3
Differences Between Relay and Individual Swim Times Across Expected Team Outcome, Serial Position, and Valence (Study 1)

Expected team outcomes	Serial position	Valence: High	Valence: Low
High	1	−0.116 [−0.121, −0.111]	−0.098 [−0.098, −0.098]
	2	0.008 [0.005, 0.011]	−0.318 [−0.318, −0.318]
	3	0.031 [0.028, 0.034]	−0.336 [−0.336, −0.336]
	4	0.202 [0.199, 0.205]	−0.175 [−0.175, −0.175]
Low	1	0.001 [−0.001, 0.003]	−0.089 [−0.089, −0.089]
	2	−0.196 [−0.198, −0.194]	−0.369 [−0.369, −0.369]
	3	−0.217 [−0.219, −0.215]	−0.389 [−0.389, −0.389]
	4	−0.075 [−0.077, −0.073]	−0.235 [−0.235, −0.235]

Note. Average differences are given in seconds. Positive values indicate effort gains, whereas negative values indicate effort losses. Numbers in parentheses denote 95% confidence intervals. Differences between relay and individual swimming times were corrected for differences between starting procedures, which had been derived empirically (see Table 1).

In a last step, we analyzed whether the swimming times observed at the different relay positions in the high-valence competitions were significantly different from zero, thus pointing to overall effort losses or gains (note that negative values of our dependent variable indicate effort losses and positive values indicate effort gains). In the high-valence, high-expectations condition, we observed significant effort losses at Position 1 (mean difference [md] = −0.116 s; 95% CI [−0.121, −0.111]), very small gains in effort at Positions 2 and 3 (mds = 0.008 s and 0.031 s, respectively; 95% CI [0.005, 0.011] and [0.028, 0.034], respectively), as well as larger effort gains at Position 4 (md = 0.202 s; 95% CI [0.199, 0.205]).[11] Thus, even after controlling for the differences in RTs between the individual and relay competitions, the swimmers in relay Position 4 swam on average 0.2 s faster than in their respective individual competitions. To highlight the practical relevance of this gain in swimming time, please note that the average time gap between the different place finishers in the 100 m freestyle individual competition in the 2012 Olympics final was 0.131 s.

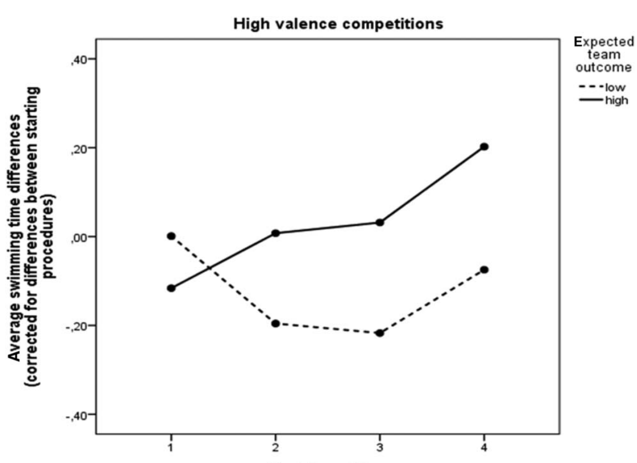

Figure 1. Average swimming time differences of individual minus relay competition time (corrected for differences between starting procedures) for the four relay positions (Study 1). Positive scores indicate effort gains in teams and negative scores indicate effort losses in teams. Error bars are omitted because of very small confidence intervals (see Table 3).

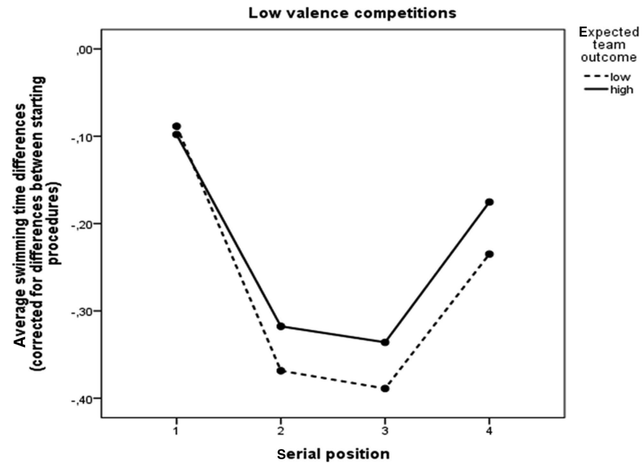

Figure 2. Average swimming time differences of individual minus relay competition time (corrected for differences between starting procedures) for the four relay positions (Study 1). Positive scores indicate effort gains in teams and negative scores indicate effort losses in teams. Error bars are omitted because of very small confidence intervals (see Table 3).

Finally, in the high-valence, low-expectations condition, the swimming times in the relays were comparable to those in the individual competitions at Position 1 and consistently slower for the remaining three positions, pointing to effort losses in the relay competitions in comparison with individual races under these conditions (see Table 3; see also Figure 2).

Discussion of Study 1 and Theoretical Background for Study 2

In Study 1, we found clear evidence for the expected overall linear increase in effort across sequentially working action teams: We observed effort losses for relay members starting at Position 1, small effort gains for the members starting at Position 2 and Position 3, as well as more pronounced effort gains for the members starting at Position 4 (a) when team members could realistically expect meaningful team outcomes in return for their team performance, and (b) when the valence of these outcomes was comparably positive in the individual and relay competitions. These results are in contrast to the conclusions of Neugart and

[11] The use of difference scores may be criticized on methodological grounds (Edwards, 2001). However, Edwards (1995) showed that the use of difference scores as dependent variable is identical to a separate treatment of two scores if a directional effect on a single dimension is assumed, which is the case in the current paper. As an alternative to using difference scores, we nevertheless conducted an analysis using a repeated-measures design. The results of the respective 4 (serial position) × 2 (expected team outcomes) × 2 (valence) × 2 (relay vs. individual performance) ANOVA with the last variable as a repeated-measures factor strongly paralleled the results on difference scores. The analysis revealed the expected four-way interaction, $F(3, 299862) = 7.80$, $p < .001$. For reasons of comprehensibility, we decided to report and decompose the three-way interaction using difference scores instead of reporting this four-way interaction.

Richiardi (2013) but consistent with the CEM as the probably most established framework to explain and predict teamwork effects on individual effort. Moreover, and also in line with the CEM, effort losses were observed at all relay positions when (a) the valence of team outcomes was lower than the valence of outcomes for individual competitions, and/or (b) it was rather unlikely to obtain meaningful team outcomes as a result of team performances (i.e., second instrumentality contingency according to the CEM).

We believe that the results of Study 1 are more realistic and precise than earlier results (Neugart & Richiardi, 2013) for at least two reasons: First, instead of assuming a general RT advantage in the relay competition, we based our analyses on empirically obtained RT estimates that were applied separately to each relay position. Second, we took into consideration that "the structure of incentives and costs" (Neugart & Richiardi, 2013, p. 192) in relay and individual competitions does in fact differ between international and national/local swimming events. In contrast to Neugart and Richiardi, we modeled this difference by adding a theoretically relevant valence factor to our study design and showed that his factor—together with others (e.g., social indispensability)—represents an important boundary condition of effort gains and losses in teams. In conclusion, the results of Study 1 reconcile Neugart and Richiardi's (2013) findings with findings from prior research that showed effort gains (Hüffmeier & Hertel, 2011; Hüffmeier et al., 2012).

The overall increase in effort across sequentially working action teams in the critical conditions of Study 1 is consistent with the serial position hypothesis, assuming that the perceived indispensability of individual contributions for the team increases with later serial positions for which compensation by other team members' performance is less likely. However, the observed results can also be explained by an alternative explanation focusing on team members' relative strength within the team. The general idea of the relative strength hypothesis (Osborn et al., 2012) is that social indispensability effects are the stronger the weaker a member is compared with her/his fellow team members. This is the case in conjunctive team tasks. In such tasks, the overall team performance is determined by the—in relation to the other team members—weakest person (Steiner, 1972). If the weakest team member is very weak in absolute terms, this obviously has a strongly negative effect on the overall team performance. It is stronger than the respective negative effect if the weakest member is only moderately weak in absolute terms. Thus, very weak team members should feel more obliged not to let their team down and exert more additional effort than moderately weak team members (e.g., Hertel et al., 2000). Although generalizability to additive team tasks might be limited, it is nevertheless conceivable that comparable processes among weaker team members also occur under additive task demands (e.g., due to fairness concerns), particularly when individual contributions are highly identifiable (which is the case in sequential teamwork). Hence, the weaker a swimmer is as compared with her/his fellow relay members, the more motivated s/he may be not to spoil the team performance through a poor individual contribution.

In Study 1 as well as in prior studies, team members' serial position and relative strength were strongly correlated (e.g., the fastest swimmers are often assigned to the first relay position; cf. Osborn et al., 2012; Hüffmeier et al., 2012) so that the available data are silent on these processes. Moreover, the CEM is also silent on the specific processes leading to perceptions of high instrumentality (or indispensability) in team contexts. Therefore, contrasting the serial position hypothesis and relative strength as a potential alternative explanation further specifies the CEM both theoretically and empirically. This was accomplished in Study 2 using data that included performance data (as behavioral indicators of effort) and data on individuals' relative strength as well as on their serial position within the relay teams.

Study 2

Method

Sampling strategy and sampling characteristics. We collected our data from an online database of U.S. college swimming events (collegeswimming.com). In addition to performance times in the individual and relay competitions, data from complete teams (i.e., data from relay and individual competitions from all four swimmers) could be sampled, which—in contrast to Study 1 and prior studies—allowed us to determine the relative strength of each swimmer in a relay team. We included all available data from the following national and supraregional championships: The National Collegiate Athletic Association (NCAA) national championships in Divisions I to III (from 2007 to 2016), the National Association of Intercollegiate Athletics (NAIA) national championships (from 2010 to 2016), the Pacific 12 (Pac-12) championships (from 2011 to 2016), and the Big Ten conference championships (from 2010 to 2016). Please note that the resulting sample was more homogenous than the sample used in Study 1. Moreover, college swimming differs from other types of competitions because all participants of the final heats in the individual and relay competitions—and not only the medalists—receive points, which count toward their university's overall championship result (for details, see for instance the NCAA's men's and women's swimming and diving rules).[12] Thus, this sampling assures that (a) all included swimmers perceived a strong relation of team performance and team outcomes, and (b) the importance, and thus the perceived valence of individual and relay competitions were comparable. Accordingly, and deviating from Study 1, we did not include these factors in the analyses of Study 2.

The necessary sample size to reliably detect a linear increase in effort across the relay was estimated as $N = 210$ (Faul, Erdfelder, Lang, & Buchner, 2007). This estimation was based on an aspired statistical power of $1 - \beta = 0.95$, a significance level of $\alpha = .05$, and an effect size of $f = 0.25$. Please note that this is a conservative estimate because prior research observed larger effect sizes in comparable analyses ($f = 0.31$ for Hüffmeier et al., 2012, and $f = 0.53$ for Osborn et al., 2012; see also the large effect size for the linear contrast testing the serial position hypothesis in Study 1).

Participants and sampling procedure. In a first step, we included all complete relays from the events listed above (i.e., each of the four swimmers participated in both the finals of the 4×100 yards relay freestyle competition as well as in the 100 yards individual freestyle competition). This procedure yielded relay and individual swimming data of 672 athletes from 168 relays. Swim-

[12] http://www.ncaapublications.com/c-61-swimming-diving.aspx (retrieved from the Internet on October 20, 2016).

mers were sampled in this first step regardless whether they qualified for the finals of the individual competition. This was done because a test of the relative strength hypothesis requires information from complete teams to clearly determine the relative strength of each swimmer in a relay team. In a second step, we determined the relative strength of each swimmer based on her/his career best time.

In a third step, we excluded 318 swimmers who did not qualify for the finals of the individual competitions. This exclusion was necessary because comparing relay swimming times derived from finals with individual swimming times derived from preliminaries would have created an artificial bias toward effort gains in teams. Another 22 swimmers had to be excluded due to incomplete data, which resulted in an overall sample of 332 cases.

In a fourth step, the relationship between relay position and relative strength of the swimmers in the remaining sample was examined. Both Osborn et al. (2012) and Hüffmeier et al. (2012) noted that swimmers' relay positions are correlated with their relative strength (e.g., the strongest swimmers often start first). In Study 2, for instance, 47% of the fastest swimmers of a relay team also swam first in the relay. A chi-square analysis confirmed that relay position and swimmer strength were correlated, $\chi^2(9) = 32.66$, $p < .001$. To disentangle potential effects of relative strength and serial position, we finally excluded all cases for which relative strength (strongest to weakest member) and serial position (1st to 4th) were identical (e.g., strongest swimmer starting at relay position 1, second strongest swimmer at position 2, etc.; for details, see Table 4). The final sample consisted of 228 swimmers (113 female) with an age range of 17 to 27 years.

Measures. We collected the performance of swimmers by sampling their swimming times in the 100 yards individual freestyle finals and the 4 × 100 yards relay freestyle finals of the same championship event. As in Study 1, we subtracted each swimmer's relay time from her/his individual competition time (i.e., positive values indicate effort gains in the relay as compared with the individual competitions, negative values effort losses). In addition to the relay starting position, we also determined the relative strength of each swimmer compared with their team members. By referring to their career best time over 100 yards, we ranked each swimmer of a relay team from 1 = *strongest* to 4 = *weakest*. This comparison standard is typically known to each member of a relay team and serves as the internal standard college athletes try to beat (Weinberg, Burton, Yukelson, & Weigand, 1993). Career records were only used if they occurred prior to the event from which the individual and relay time data were sampled. In the remaining cases, we used the second-best time of a swimmer's career to determine her/his relative strength instead. These second-best times always occurred prior to the sampled events.

Reaction time correction. Considering that the collegiate swimmers in our sample are more diverse than the professional swimmers in the critical conditions of Study 1, we used different data to correct for RT advantages in the relay competition (Filusch, Schleu, & Hüffmeier, 2017). In their study, Filusch et al. collected data from 2,084 swimmers from diverse swimming sports events (e.g., World Youth championships, European Youth Championships, Speedo Junior National Championships, Universiade, U.S. Open, Pan Pacific Games, Commonwealth Games, FINA World Cup, European Championships, Olympic Games) using the same web platforms as in our pilot study. Data were only considered if RTs for the 100 m individual and the 4 × 100 m relay freestyle competition of the same sports event were available. Different to the pilot study, the data from Filusch et al. were originally not collected to estimate RT advantages in the relay competition. Therefore, this data is not stratified and entails unequal case numbers per gender and per relay position (see Table 5). The RT advantages observed in this study were largely comparable to those obtained in our pilot study, but slightly smaller by trend (ranging from 0.434 s to 0.465 s; cf. Table 5). To correct for the different starting procedures, we used these mean RT advantages for every swimming position (again separately for women and men).

Table 4
Sample of Study 2 as a Function of Team Members' Relative Strength and Serial Position

	Serial position in the relay				
Relative strength	1	2	3	4	Total
Strongest	0	21	14	28	63
Second strongest	21	0	16	24	61
Third strongest	12	18	0	27	57
Weakest	12	18	17	0	47
Total	45	57	47	79	228

Note. Cases where relative strength and serial position were completely confounded were removed (see the diagonal).

Results

Serial position hypothesis. A Levene test did not reveal inequality of variances between positions, $F(3, 224) = 1.87$, $p = .136$. A one-way ANOVA showed that serial positions significantly accounted for performance differences in swimmers, $F(3, 224) = 9.57$, $p < .001$. As specific hypothesis test, we applied a planned contrast (Rosenthal & Rosnow, 1985) by assigning the following contrast coefficients: Serial Position 1 [−3], Position 2 [−1], Position 3 [1], and Position 4 [3]. This contrast analysis confirmed the predicted linear increase in performance across the relay, $t(224) = 5.36$, $p < .001$ (see Figure 3). While relay swimmers at Position 1 ($M = -0.17$, $SD = 0.61$) showed an insignificant trend toward performance losses as compared with their individual competitions, $t(44) = -1.85$, $p = .071$, $d = -0.28$, swimmers at Position 2 performed equally well in the relay and individual competitions, $M = 0.11$, $SD = 0.53$, $t(56) = 1.58$, $p = .12$, $d = 0.21$. However, significant performance gains as compared with individual competitions occurred for relay swimmers at Position 3, $M = 0.32$, $SD = 0.58$, $t(46) = 3.70$, $p = .001$, $d = 0.54$, and at Position 4, $M = 0.41$, $SD = 0.66$, $t(78) = 5.46$, $p < .001$, $d = 0.61$. Overall, these results support the serial position hypothesis.

Relative strength explanation. For the analysis on team members' relative strength, a Levene test again did not reveal inequality of variances, $F(3, 224) = 2.44$, $p = .066$. A one-way ANOVA with relative strength as a four-level independent variable (strongest, second strongest, third strongest, and weakest team members) did not reveal a significant effect, $F(3, 224) = 0.71$, $p = .544$. In the ensuing contrast analysis, we used the following contrast coefficients: The strongest swimmers of a relay [−3], the

Table 5
Reaction Time Differences Between the Individual and Relay 100 Meter Competitions (Individual Minus Relay Reaction Time) as a Function of Gender and Serial Position (Study 2)

Gender	Serial position	Time difference	N
Female	1	−0.007 (0.06)	328
	2	0.434 (0.14)	213
	3	0.439 (0.16)	126
	4	0.436 (0.16)	262
Male	1	−0.006 (0.04)	411
	2	0.465 (0.14)	273
	3	0.455 (0.16)	171
	4	0.463 (0.14)	300

Note. Reaction time differences are given in seconds. Numbers in parentheses denote standard deviations.

second strongest swimmers [−1], the third strongest swimmers [1], and the weakest swimmers [3]. This contrast did not show a linear increase in performance across the relay, $t(224) = -.52$, $p = .602$ (see Figure 4).

As an alternative to the relative strength explanation examined above, one might expect a curvilinear relation between team members' capability and effort (e.g., Messé, Hertel, Kerr, Lount, & Park, 2002). Specifically, if the discrepancy of capabilities within a team is large, the weakest members might exert only low effort because they do not expect to achieve the performance level of the other team members, no matter how hard they try. Such effects due to a low expectancy component are conceivable even when the perceived instrumentality of the individual contribution to the team is high. To test this alternative version of a relative strength explanation, we conducted a last contrast analysis using the following coefficients: The strongest swimmers of a relay [−1], the second strongest swimmers [1], the third strongest swimmers [1], and the weakest swimmers [−1]. This contrast did not show a curvilinear increase in performance across the relay, $t(224) = 1.39$, $p = .167$. Together, these results are inconsistent with the notion that relative strength drives the observed effort increases in the swimming relays as compared with individual competitions.

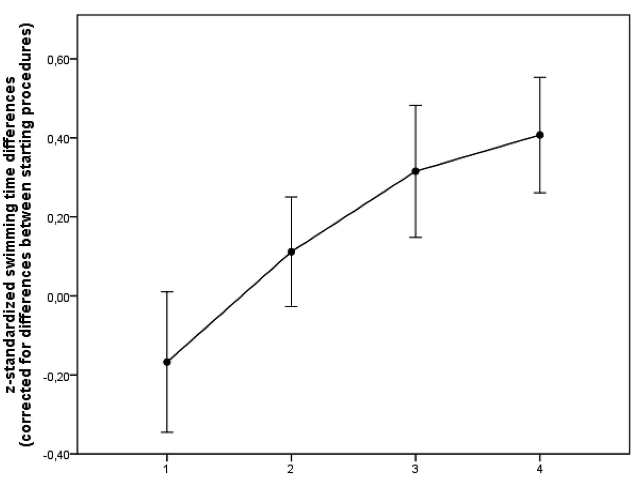

Figure 3. z-standardized swimming time differences of individual minus relay competition time (corrected for differences between starting procedures) for the four relay positions (Study 2). z-standardization was conducted to center scores within different championships and for female and male swimmers. Cases where serial position and relative strength were identical were removed. Positive scores indicate effort gains in teams and negative scores indicate effort losses in teams. Error bars represent 95% confidence intervals ($N = 228$).

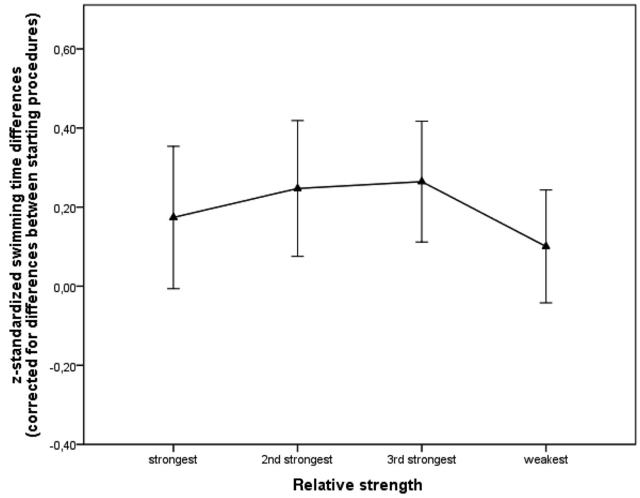

Figure 4. z-standardized swimming time differences of individual minus relay competition time (corrected for differences between starting procedures) for the four levels of swimmers' relative strength (Study 2). z-standardization was conducted to center scores within different championships and for female and male swimmers. Cases where relative strength and serial position were identical were removed. Positive scores indicate effort gains in teams and negative scores indicate effort losses in teams. Error bars represent 95% confidence intervals ($N = 228$).

Discussion of Study 2

In Study 2, we considered two different explanations how effort gains in teams might come about, further developing and specifying the CEM both theoretically and empirically. Whereas the serial position hypothesis stresses the anticipated likelihood that following team partners might compensate poor performance, the relative strength hypothesis focuses on the specific handicap that especially weak team members might implicate for the overall team result. In all prior studies, team members' serial position and relative strength were strongly correlated (Hüffmeier et al., 2012; Neugart & Richiardi, 2013; Osborn et al., 2012). To the best of our knowledge, Study 2 is the first empirical work that disentangled the effects of team members' serial position and relative strength on effort gains in teams. The results clearly support the serial position as effective driver for the steady increase in effort across the relays. By contrast, the hypothesis that effort gains in teams are (either linearly or curvilinearly) correlated with the relative strength of weaker team members (Osborn et al., 2012; see also Messé et al., 2002) did not receive empirical support in the current study.

General Discussion

In this research, we examined actual effort expenditure in action teams with a sequential structure in high-stakes settings and sought to integrate research on effort losses and gains in these teams as compared with individual work. Theoretically, this research builds on the CEM (Karau & Williams, 1993, 2001) and previously untested hypotheses on the emergence of effort gains in teams (Karau et al., 2000). However, we also extended the CEM by testing two alternative explanations how motivating indispensability effects might occur in sequential teamwork.

As predicted and reflecting the serial position hypothesis, we found effort gains in Study 1 when (a) there was a good chance to obtain meaningful team outcomes in return for a strong performance and (b) when these outcomes were at least equally attractive as in the individual competition. If these favorable conditions were not given, we consistently found effort losses. The results of Study 2 corroborated the serial position hypothesis, while we did not find evidence for relative strength as an alternative explanation of effort gains in sequentially working teams.

Theoretical Implications

The main theoretical conclusions of this research are as follows: First, being indispensable for the team outcome is a motivator for individuals also in sequential action teams, leading to significant effort gains as compared with working individually. Effort gains in relay as compared with individual competitions continuously increased across relay positions in both studies, parallel to respective instrumentality perceptions shown in earlier research (Hüffmeier & Hertel, 2011). If all or most of the other components of the CEM (Karau & Williams, 1993) are pronounced (and none of the non-pronounced factors are weak or even zero), such effort gains emerged in teams as compared with individual work. However, if at least one of the remaining perceived relations was weak or not even given, effort losses were observed. In sum, we could confirm the valence hypothesis put forth in an advancement of the CEM (Karau et al., 2000), and we could show that the equivalency of outcomes in individual work and teamwork has to be accompanied with high instrumentality to generate effort gains in teams.

Second, we could exclude a prominent alternative explanation of team effort gains by showing that the increase in effort across the relay was triggered by the members' serial position and not by their relative strength within the relay. This is consistent with the general idea that, due to the additive and sequential nature of the focused action team task, performances become less compensable the later a member works in the team sequence. Consequently, one's own contribution to the team performance is increasingly indispensable with later serial positions (Hüffmeier & Hertel, 2011; see also Au et al., 1998). By contrast, effects of relative partner strength seem to be more prevalent in conjunctive (or disjunctive) team tasks where inferior (or superior) team members determine their team's performance (e.g., Karau & Williams, 1993; Kerr & Hertel, 2011; Messé et al., 2002).

Practical Implications

Our study suggests a couple of starting points to optimize individual team members' motivation and, as a consequence, team performance as well. The perception of each individual team member that his or her own contribution to the team's performance matters (i.e., perceived indispensability) seems to be especially relevant. It might thus be crucial for team managers to influence these perceptions with appropriate team staffing, work-design measures, and feedback behavior (e.g., Hertel, Konradt, & Orlikowski, 2004). However, another major conclusion from our results is that social indispensability is not sufficient when context conditions are not supportive. For instance, a strong team performance has to be connected with a realistic chance to achieve positive outcomes for the team, and these outcomes need to be at least as attractive as those that can be achieved in individual work (Karau et al., 2000).

The effect sizes of the demonstrated team effort gains most likely represent a rather conservative estimate because professional athletes are already maximally motivated in their individual races. The observed effort gains in teams even under such difficult circumstances suggest that the motivating effect of social indispensability in teams may be even more pronounced in more typical workplace teams working under conditions of sequential interdependence. Such conditions are more frequent in workplace teams than it might seem at a first glance (Cannon-Bowers & Bowers, 2006). These teams may become even more prevalent, such as, for instance, virtual teams with international "follow-the-sun" or "around-the-clock" work flows (Carmel, Espinosa, & Dubinsky, 2010), teams working along a supply chain (cf. Lazzarini, Chaddad, & Cook, 2001), or teams in e-commerce contexts that process "orders from receipt through delivery" (cf. Cannon-Bowers & Bowers, 2006, p. 450). We believe that our results are generalizable to these and similar types of teams.

Limitations and Future Research

Our research has several limitations. Similar to prior studies on this topic (e.g., Hüffmeier & Hertel, 2011; Neugart & Richiardi, 2013), we interpreted differences in swimming performances as indicative of expended effort. For the trained athletes in our sample, this interpretation may be justifiable because, for them, swimming performance may be a direct function of expended effort (and not so much of, for instance, skill or intelligence; cf. Hertel et al., 2000). However, future research should combine behavioral data with additional effort indicators (e.g., physiological data, self-report data) to collect more evidence that this interpretation is in fact tenable.

We operationalized the different factors in our study by assigning specific swimming performances to the different study conditions (perceived relation between individual and team performances, expected team outcomes, and valence) based on logical reasoning. Obviously, measuring swimmers' perceptions would have been preferable. On the other hand, it appears reasonable to assume, for instance, that swimmers whose relays placed first to fourth perceived on average a stronger relation between their team's performance and the potential for a positive team outcome than did the swimmers of teams that placed lower. Similarly, relay swimmers in national championships who knew in advance that they could not qualify for upcoming international championships, even with a very good performance, most likely perceived the valence of their outcomes as less attractive than individual swimmers who could both become champion and qualify.

At first glance, teams in our research may not be not representative of "typical" work teams because they had to engage in maximal rather than typical performance (Sackett et al., 1988). However, the distinction between maximal and typical performance may not be as clear for many of today's jobholders as it may have been in the past. For instance, in a large recent European survey, approximately one third of the interviewed 35,000 jobholders reported that their work is characterized by the need to work very quickly at least for 75% of their working time (Eurofound, 2015). And more specifically, requirements of maximum performance may be more frequent in teams than it seems at first glance. For instance, the research literature has linked military teams (Lim & Ployhart, 2004) or teams composed of MBA students working on a common project (Klehe & Latham, 2006) to maximum performance requirements. Moreover, working conditions that trigger maximum performance can also be observed across a range of other teamwork contexts, including audit or consulting teams (Gardner, 2012), medical teams (Xiao et al., 1996), and software development teams (Maruping, Venkatesh, Thatcher, & Patel, 2015). Thus, the working conditions of our teams that require maximum performance may be representative of those of many current jobholders in general and of a number of different teams in particular.

The aspect of sequential teamwork (and the related sequential interdependence; Thompson, 1967) could also be considered to limit the generalizability of our research. However, there is emerging evidence that the psychological mechanisms driving effort gains in sequential teamwork also generalize to nonsequentially working teams without a high visibility of individual contributions. Specifically, although the perception of social indispensability increases with later positions during sequential work (Hüffmeier & Hertel, 2011), it does not seem to be tied exclusively to sequential workflows. In fact, recent work has also shown a motivating effect of teamwork due to social indispensability in a mixed sample of employees from teams with nonsequential workflows (Hertel et al., 2017).

Finally, it is important to note that the limitations of our study are balanced by the methodological advantages of analyzing archival data. Most importantly, this type of research avoids the typical problems found in field studies, such as the effects of merely observing people (i.e., the Hawthorne effect; Roethlisberger & Dickson, 1939), social desirability considerations (Crowne & Marlowe, 1960), and demand effects (Orne, 1962).

Conclusion

As predicted by the CEM (Karau et al., 2000; Karau & Williams, 1993), our archival analysis of more than 300,000 swimming performances provides evidence for the idea that effort gains in teams are likely to emerge when team members expect meaningful team outcomes in return for their performance and when the valence of these outcomes is comparable to outcomes in individual work. In an extension of the CEM, our results also show that in sequentially working teams the team members' serial position rather than their relative strength is responsible for effort gains during team- as compared with individual work. In conclusion, our results demonstrate that teamwork can be a crucial source of effort gains even in high-stakes settings contingent on details of the context conditions, which can be directly addressed by those seeking to optimize team performance.

References

Asendorpf, J. B., Conner, M., De Fruyt, F., De Houwer, J., Denissen, J. A., Fiedler, K., . . . Wicherts, J. M. (2013). Recommendations for increasing replicability in psychology. *European Journal of Personality, 27,* 108–119. http://dx.doi.org/10.1002/per.1919

Au, W. T., Chen, X.-P., & Komorita, S. S. (1998). A probabilistic model of criticality in a sequential public good dilemma. *Organizational Behavior and Human Decision Processes, 75,* 274–293. http://dx.doi.org/10.1006/obhd.1998.2795

Campbell, J. P. (1990). Modeling the performance prediction problem in industrial and organizational psychology. In M. D. Dunnette & L. M. Hough (Eds.), *Handbook of industrial and organizational psychology* (2nd ed., Vol. 1, pp. 687–732). Palo Alto, CA: Consulting Psychologists Press.

Cannon-Bowers, J. A., & Bowers, C. (2006). Applying work team results to sports teams: Opportunities and cautions. *International Journal of Sport and Exercise Psychology, 4,* 447–462. http://dx.doi.org/10.1080/1612197X.2006.9671807

Carmel, E., Espinosa, J. A., & Dubinsky, Y. (2010). "Follow the sun" workflow in global software development. *Journal of Management Information Systems, 27,* 17–38. http://dx.doi.org/10.2753/MIS0742-1222270102

Crowne, D. P., & Marlowe, D. (1960). A new scale of social desirability independent of psychopathology. *Journal of Consulting Psychology, 24,* 349–354. http://dx.doi.org/10.1037/h0047358

Edwards, J. R. (1995). Alternatives to difference scores as dependent variables in the study of congruence in organizational research. *Organizational Behavior and Human Decision Processes, 64,* 307–324. http://dx.doi.org/10.1006/obhd.1995.1108

Edwards, J. R. (2001). Ten difference score myths. *Organizational Research Methods, 4,* 265–287. http://dx.doi.org/10.1177/109442810143005

Eurofound. (2015). *First findings: Sixth European Working Conditions Survey* (Reference No. EF1568). Retrieved from the Eurofound website: https://www.eurofound.europa.eu/publications/resume/2015/working-conditions/first-findings-sixth-european-working-conditions-survey-resume

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39,* 175–191. http://dx.doi.org/10.3758/BF03193146

Filusch, M. A., Schleu, J. E., & Hüffmeier, J. (2017). Effort gains and losses in relay swimming. Unpublished raw data.

Gardner, H. K. (2012). Performance pressure as a double-edged sword: Enhancing team motivation but undermining the use of team knowledge. *Administrative Science Quarterly, 57,* 1–46. http://dx.doi.org/10.1177/0001839212446454

Geen, R. G. (1995). *Human motivation: A social psychological approach*. Pacific Grove, CA: Brooks/Cole.

Hertel, G., Kerr, N. L., & Messé, L. A. (2000). Motivation gains in performance groups: Paradigmatic and theoretical developments on the Köhler effect. *Journal of Personality and Social Psychology, 79,* 580–601. http://dx.doi.org/10.1037/0022-3514.79.4.580

Hertel, G., Konradt, U., & Orlikowski, B. (2004). Managing distance by interdependence: Goal setting, task interdependence, and team-based rewards in virtual teams. *European Journal of Work and Organizational Psychology, 13,* 1–28. http://dx.doi.org/10.1080/13594320344000228

Hertel, G., Nohe, C., Wessolowski, K., Meltz, O., Brahm, J., Fink, J., & Hüffmeier, J. (2017). *When (and why) is teamwork more motivating than working alone? Social comparison and social indispensability effects in existing teams at work*. Manuscript submitted for publication.

Hüffmeier, J., & Hertel, G. (2011). When the whole is more than the sum of its parts: Group motivation gains in the wild. *Journal of Experimental*

Social Psychology, 47, 455–459. http://dx.doi.org/10.1016/j.jesp.2010.12.004

Hüffmeier, J., Krumm, S., Kanthak, J., & Hertel, G. (2012). "Don't let the group down": Facets of instrumentality moderate the motivating effects of groups in a field experiment. *European Journal of Social Psychology, 42,* 533–538. http://dx.doi.org/10.1002/ejsp.1875

Ishak, A. W., & Ballard, D. I. (2012). Time to re-group: A typology and nested phase model for action teams. *Small Group Research, 43,* 3–29. http://dx.doi.org/10.1177/1046496411425250

Karau, S. J., Markus, M. J., & Williams, K. D. (2000). On the elusive search for motivation gains in groups: Insights from the Collective Effort Model. *Zeitschrift für Sozialpsychologie, 31,* 179–190. http://dx.doi.org/10.1024//0044-3514.31.4.179

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. http://dx.doi.org/10.1037/0022-3514.65.4.681

Karau, S. J., & Williams, K. D. (1997). The effects of group cohesiveness on social loafing and social compensation. *Group Dynamics: Theory, Research, and Practice, 1,* 156–168. http://dx.doi.org/10.1037/1089-2699.1.2.156

Karau, S. J., & Williams, K. D. (2001). Understanding individual motivation in teams: The collective effort model. In M. E. Turner (Ed.), *Groups at work: Theory and research* (pp. 113–141). Mahwah, NJ: Erlbaum Publishers.

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. http://dx.doi.org/10.1111/j.1751-9004.2010.00333.x

Kidwell, R. E., & Bennett, N. (1993). Employee propensity to withhold effort: A conceptual model to intersect three avenues of research. *The Academy of Management Review, 18,* 429–456.

Klehe, U. C., & Latham, G. (2006). What would you do—Really or ideally? Constructs underlying the behavior description interview and the situational interview in predicting typical versus maximum performance. *Human Performance, 19,* 357–382. http://dx.doi.org/10.1207/s15327043hup1904_3

Lazzarini, S., Chaddad, F., & Cook, M. (2001). Integrating supply chain and network analyses: The study of netchains. *Journal on Chain and Network Science, 1,* 7–22. http://dx.doi.org/10.3920/JCNS2001.x002

Lim, B. C., & Ployhart, R. E. (2004). Transformational leadership: Relations to the five-factor model and team performance in typical and maximum contexts. *Journal of Applied Psychology, 89,* 610–621. http://dx.doi.org/10.1037/0021-9010.89.4.610

Lount, R. B., Jr., & Wilk, S. L. (2014). Working harder or hardly working? Posting performance eliminates social loafing and promotes social laboring in workgroups. *Management Science, 60,* 1098–1106. http://dx.doi.org/10.1287/mnsc.2013.1820

Maruping, L. M., Venkatesh, V., Thatcher, S. M. B., & Patel, P. C. (2015). Folding under pressure or rising to the occasion? Perceived time pressure and the moderating role of team temporal leadership. *Academy of Management Journal, 58,* 1313–1333. http://dx.doi.org/10.5465/amj.2012.0468

Messé, L. A., Hertel, G., Kerr, N. L., Lount, R. B., Jr., & Park, E. S. (2002). Knowledge of partner's ability as a moderator of group motivation gains: An exploration of the Köhler discrepancy effect. *Journal of Personality and Social Psychology, 82,* 935–946. http://dx.doi.org/10.1037/0022-3514.82.6.935

Neugart, M., & Richiardi, M. G. (2013). Sequential team work in competitive environments: Theory and evidence from swimming data. *European Economic Review, 63,* 186–205. http://dx.doi.org/10.1016/j.euroecorev.2013.07.006

Orne, M. T. (1962). On the social psychology of the psychology experiment: With particular reference to demand characteristics and their implications. *American Psychologist, 17,* 776–783. http://dx.doi.org/10.1037/h0043424

Osborn, K. A., Irwin, B. C., Skogsberg, N. J., & Feltz, D. L. (2012). The Köhler effect: Motivation gains and losses in real sports groups. *Sport, Exercise, and Performance Psychology, 1,* 242–253. http://dx.doi.org/10.1037/a0026887

Roethlisberger, F. J., & Dickson, W. J. (1939). *Management and the worker*. Cambridge, MA: Harvard University Press.

Rosenthal, R., & Rosnow, R. L. (1985). *Contrast analysis: Focused comparisons in the analysis of variance*. New York, NY: Cambridge University Press.

Sackett, P. R., Zedeck, S., & Fogli, L. (1988). Relations between measures of typical and maximum job performance. *Journal of Applied Psychology, 73,* 482–486. http://dx.doi.org/10.1037/0021-9010.73.3.482

Silberzahn, R., Uhlmann, E. L., Martin, D. P., Pasquale, Aust, F., Awtrey, E. C., . . . Nosek, B. A. (2015, August 20). *Final Reports*. Retrieved from osf.io/qix4g

Simmons, J. P., Nelson, L. D., & Simonsohn, U. (2011). False-positive psychology: Undisclosed flexibility in data collection and analysis allows presenting anything as significant. *Psychological Science, 22,* 1359–1366. http://dx.doi.org/10.1177/0956797611417632

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

Sundstrom, E. (1999). The challenges of supporting work team effectiveness. In E. Sundstrom (Ed.), *Supporting work team effectiveness: Best management practices for fostering high performance* (pp. 3–23). San Francisco, CA: Jossey-Bass.

Sundstrom, E., DeMeuse, K., & Futrell, D. (1990). Work teams: Applications and effectiveness. *American Psychologist, 45,* 120–133. http://dx.doi.org/10.1037/0003-066X.45.2.120

Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics*. Boston, MA: Pearson.

Thompson, J. D. (1967). *Organizations in action*. New York, NY: McGraw-Hill.

Weber, B., & Hertel, G. (2007). Motivation gains of inferior group members: A meta-analytical review. *Journal of Personality and Social Psychology, 93,* 973–993. http://dx.doi.org/10.1037/0022-3514.93.6.973

Weinberg, R., Burton, D., Yukelson, D., & Weigand, D. (1993). Goal setting in competitive sport: An exploratory investigation of practices of collegiate athletes. *The Sport Psychologist, 7,* 275–289. http://dx.doi.org/10.1123/tsp.7.3.275

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. http://dx.doi.org/10.1037/0022-3514.61.4.570

Wittchen, M., Schlereth, D., & Hertel, G. (2007). Indispensability effects in a sequential task: Motivation gains during anonymous cooperation on the Internet. *International Journal of Internet Science, 2,* 12–27.

Xiao, Y., Hunter, W. A., Mackenzie, C. F., Jefferies, N. J., Horst, R. L., & the LOTAS Group. (1996). Special Section: Task complexity in emergency medical care and its implications for team coordination. *Human Factors, 38,* 636–645. http://dx.doi.org/10.1518/001872096778827206

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