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Ethological observations of social behavior in the operating room

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Operating rooms (ORs) are inhabited by hierarchical, mixed-gender clinical teams that are often prone to conflict. In evolutionary terms, one expects more within- than between-gender rivalries, especially since the OR is a place where all sorts of social interactions occur, not merely technical communications. To document the full range of behavior, the present study used ethological observation techniques, recording live all social behavior by the team. Using an ethogram, 6,348 spontaneous social interactions and nontechnical communications were timestamped during 200 surgical procedures. Cooperation sequences (59.0%) were more frequent than conflict sequences (2.8%), which ranged from constructive differences of opinion to discord and distraction that could jeopardize patient safety. Behavior varied by clinical role and with the gender composition in the OR. Conflict was initiated mostly down the hierarchy between individuals several ranks apart. Cooperation tended to increase with a rising proportion of females in the OR, but the most pronounced effect concerned the interaction between both genders. If the attending surgeon's gender differed from that of the majority of other personnel in the OR, cooperation was significantly more common.

medical | human behavior | gender | operating room | conflict

The hospital operating room (OR) brings individuals of both genders together around a complex task. In modern society, this is not unusual, but it deviates from most of human history and prehistory. Humanity has an evolutionary background of same-gender teamwork, such as the well-documented masculine coalitions for hunting and warfare (1, 2) and mutually supportive alloparenting by women (3). Mixed-gender teamwork, on the other hand, especially under pressure, may have been rare during our past. However, it is common in the OR. To complicate matters, the OR team membership changes constantly (4) and hence lacks the established long-term relationships and routine role divisions that mark most human cooperation. That conflict in the OR is more common in larger than in smaller institutions (5) may relate to this issue of interpersonal familiarity.

Conflict is an inevitable, sometimes constructive part of cooperation, and all organizations need to find a balance between conflict and cooperation (6). Gottman (7) has proposed that successful marriages are marked by a "magic" 5:1 ratio between positive and negative interactions, a ratio that also appears to mark successful cooperation in other primates (8). Nevertheless, conflict poses serious problems and liabilities. During a single OR procedure, an average of four conflicts occur (9), which sometimes escalate to the point of jeopardizing patient safety (10–12).

Social relationships are often at the root of conflicts, such as when someone's status is being threatened or when roles are ill-defined (5). This is why the best way to understand OR conflict is to investigate all social behavior in the room, not just conflicts. Decades ago, Donabedian (13) identified two elements comprising clinical performance: (*i*) technical (i.e., knowledge and skill), and (*ii*) interpersonal (i.e., information exchange via communication). There is, however, a wider range of behavior observable in the OR, all of which affects cooperation and conflict. People in the OR engage in pleasantries, gossip, verbal insults, professional exchanges, teaching, flirtation, and even dance, because music is often played. We need a methodology that takes all these behaviors into account.

The objective here was to look at OR behavior the way ethologists do, by focusing on hierarchy and gender. Ethology is the study of humans and other species from an evolutionary perspective based on records of natural behavior. One overall lesson from evolutionary biology is that not only cooperation (see above for humans) but also rivalries are more common within than between genders. Males evolved to compete with each other, and rarely with females, over mates and status. Females, too, often perceive members of their own gender as rivals. For this reason, status matters most within each gender, because this is where social hierarchies both mitigate and generate conflict. It also matters if the alpha individual is of the same or a different gender than most other individuals in the group, because the need to assert status mostly concerns one's own gender. At the same time, the relation between genders is subject to pronounced cultural influences, such as norms of privilege or chivalry. One reported gender difference is that high-ranking men express themselves verbally more (are more voluble) than high-ranking women (14). With increasing gender diversity in the OR, we can therefore expect the dynamics of conflict and cooperation to change.

Large-scale systematic data derived from direct behavioral observations in the OR are limited. Recently published formal "taxonomies" barely address spontaneous social interaction (15, 16).

Significance

Hierarchy and gender composition affect the balance of cooperation and conflict on surgical teams. In this investigation, behavior was quantified with methods traditionally used to study nonhuman primate groups. Observers used an ethogram to timestamp 6,348 spontaneous social interactions from 200 surgical procedures. Conflict and cooperation in the operating room showed a significant interaction effect with regard to professional roles (e.g., conflict was initiated mostly down the hierarchy between individuals several ranks apart) and by gender interaction (e.g., cooperation was better if the attending surgeon's gender differed from that of the team majority). These findings may inform ongoing and future interventions designed to improve team performance and patient safety.

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Table 1. Descriptive statistics for 200 observed surgeries

Measure	N	Median or mean (SD) or % of cases*	Interquartile range		Range	
			25th	75th	Min	Max
Social communications per surgery	200	23.0	13.3	42.8	2	163
Total length of surgery, min[†]	200	71.6	34.9	124.8	7.4	280.2
Percent males in room	200	38.1 (23.4)			0	100
Age of attending surgeon[‡]	197	49.1 (11.0)			32	80
Gender of attending surgeon – Male	154	77.0%				
Academic affiliation attending surgeon – Faculty	162	81.0%				
Surgical department[§]						
General	61	30.5%				
Neurosurgery	30	15.0%				
Cardiothoracic	23	11.5%				
Otolaryngology	21	10.5%				
Gynecology	18	9.0%				
Urology	17	8.5%				
Vascular	15	7.5%				
Orthopedics	15	7.5%				

Max, maximum; Min, minimum; N, number.

*Rows 1 and 2 give the median; rows 3 and 4 give the mean (SD); all other rows give the percentage of cases.

[†]The duration of the procedure began with the surgical call to order/timeout and lasted until the last social communication occurred before the final drape removal. Short cases were not uncommon.

[‡]Age was not obtained for three surgeons.

[§]Small departments were grouped with larger ones in related specialties (e.g., Pain Management was combined with Neurosurgery).

From our preliminary observations, we determined that the majority of OR communication neither directly nor indirectly concerned case-related information. Rather, the majority pertained to the clinicians' personal lives, current events, and popular culture. Conflict, moreover, often seemed related to power negotiations and social relationships. We focused on interprofessional, rather than intraprofessional, communication, because the majority of miscommunications in health care are between clinicians in different professional roles (11, 17).

We developed an OR ethogram (18), which offered a list of well-defined nontechnical, interprofessional communication behaviors—from small talk to confrontation and from playfulness to flirting—that we could reliably observe in the OR. Making use of modern hand-held equipment (19), we preassigned letter codes to all 28 behaviors and to each of the seven most common types of OR team members in the ethogram, with time-stamped data being typed in live on an iPad using Neukadye's Time-stamped Field Notes (Table S1 provides the full ethogram). Each social interaction was coded as a triad of who (the source of a behavior) does what (the behavior) to whom (the recipient). The majority of observations were collected by a single observer (L.K.J.), but the ethogram's reliability was evaluated by a pair of trained observers who worked independently from different vantage points in the room. Using Cohen's Kappa coefficient, a robust measure of agreement, interobserver reliability was 81% for behaviors and 89% for actors (18). Kappa coefficients of 0.80 and higher are generally accepted as indicating a high degree of agreement (20).

For the present analysis, we collapsed behavior in the OR ethogram into three types: cooperation, conflict, or neither. Although much behavior fell into the neither category, for the present analysis we examined the opposite ends of the behavioral spectrum: cooperation vs. conflict. Cooperation was defined as affiliative behavior and team building, typically including chit-chat, exchanging pleasantries, bilateral joking, and teaching by more experienced to less experienced team members. Conflict was defined as team-disintegrating communications, including yelling, being curt or disrespectful, and unilateral joking.

Two hundred surgical cases were observed from 2014 to 2016 at three urban teaching hospitals in the same state, located two to six driving miles from each other. Sixty-eight percent of the cases were open surgeries, and 32% were laparoscopic surgeries. We recorded a total of 6,348 communications. At least 400 different clinicians participated, including attending surgeons, surgical fellows or residents, anesthesia providers (anesthesiologists, certified registered nurse anesthetists, and anesthesia assistants), circulating nurses, and surgical scrub persons (registered nurses or technicians). We attempted low replication of persons acting as the attending surgeon by not observing any individual in this role more than four times. We also reduced oversampling of repeated events by considering repeated behavior less than 3 min apart as a single event. The study protocol was reviewed and approved by the IRB of Emory University. Because patients were not a part of data collection, the IRB deemed their consent unnecessary. Researchers obtained verbal assent to observe each team member in the OR prior to the start of the procedure. If team members declined (2% of cases), researchers left the OR without data collection.

Statistical Analysis

After data were reviewed for completeness, implausible values, and normality assumptions, descriptive statistics were calculated (including means and SDs for normally distributed measures, as well as medians and interquartile ranges for measures with skewed distributions). Statistical analyses and associated graphics visualizations were performed at the 0.05 significance level using SPSS v.23 (21) and R v.3.3.2 (22).

Generalized multilevel models (GzMLMs) were employed treating the individually observed behaviors as level 1 nested within surgery and as level 2 for the binary outcome of interest (cooperation vs. all other behavior or conflict vs. all other behavior) using the SPSS GENLINMIXED procedure (23, 24). These GzMLMs were used to account for the hierarchical, nested structure of the data and to adjust for the varying numbers of behaviors observed per surgery. Two separate comprehensive GzMLM models were run, one for cooperation behaviors and one for conflict behaviors, to determine the impact and interaction

Table 2. Behavior divided by source and recipient, with frequencies and percentages (in parentheses) for all 6,348 observed communications

Interactant	Conflict	Cooperation	Neither	Total
All communications	175 (2.8)	3,745 (59.0)	2,428 (38.2)	6,348
Source				
Anesthesia provider	10 (5.7)	218 (5.8)	204 (8.4)	432 (6.8)
Attending surgeon	118 (67.4)	2,026 (54.1)	796 (32.8)	2,940 (46.3)
Circulating nurse	21 (12.0)	619 (16.5)	554 (22.8)	1,194 (18.8)
Scrub nurse	5 (2.9)	355 (9.5)	470 (19.4)	830 (13.1)
Surgical resident	21 (12.0)	527 (14.1)	404 (16.6)	952 (15.0)
Recipient				
Anesthesia provider	19 (10.9)	264 (7.0)	128 (5.3)	411 (6.5)
Attending surgeon	20 (11.4)	448 (12.0)	440 (18.1)	908 (14.3)
Circulating nurse	46 (26.3)	520 (13.9)	368 (15.2)	934 (14.7)
Everyone	21 (12.0)	457 (12.2)	757 (31.2)	1,235 (19.5)
Scrub nurse	33 (18.9)	494 (13.2)	331 (13.6)	858 (13.5)
Surgical resident	36 (20.6)	1,562 (41.7)	404 (16.6)	2,002 (31.5)

between the source and recipient roles and between the attending surgeon's gender and the percentage of males in the OR as well as the temporal effect (elapsed time of surgery). All 6,348 observed communications were coded as cooperative, conflict, or neither. For the cooperation model, the response was coded 1 for cooperative behavior and 0 for conflict or neither. For the conflict model, the response was coded 1 for conflict behavior and 0 for cooperative or neither. Both comprehensive models used a binary response with a logit link function.

Level 1 covariates were the role of an individual on the surgical team [i.e., attending surgeon, surgical fellow/resident, anesthesia provider, circulating nurse, scrub nurse, or everyone (considered as recipient only)] for the source and recipient of each observed behavior plus the elapsed time (in minutes) from the start of the surgery for each observed behavior. Elapsed time in minutes was divided into 10-min segments to allow better interpretation of the odds ratios estimated from the final model. The surgery-dependent (level 2) covariates were department (Table 1), the attending surgeon's gender, age, and academic affiliation (i.e., faculty member or community hospital-based surgeon), and the gender composition of the surgical team for that procedure. To determine the team's gender composition, the percentage of males in the room was computed, excluding the attending surgeon because this individual's gender was already recorded and modeled separately. Because handoffs among OR personnel were frequent, we recorded the gender of the clinician who performed in each role in the room for the longest duration of time.

The GzMLM models were run treating surgery as a random effect, with elapsed time, source, recipient, source × recipient interaction, attending surgeon's gender, percentage of males in room, and attending surgeon's gender × percentage of males in room interactions as fixed effects. More details on the final choice of model covariates and post hoc analyses are provided in *Supporting Information*. The degrees of freedom were computed using the Satterthwaite method (24).

Results

Table 1 provides descriptive statistics of the number of social communications observed per surgery case, including information about case length, the gender composition of the OR team, the age, gender, and academic affiliation of the attending surgeon, and surgical department. The shortest observed surgery was 7.4 min with only two communications observed, and the longest was 280.2 min with 163 communications, the maximum observed. The age of the attending surgeon ranged from 32 to 80 y, averaging 49.1 y. Most of the attending surgeons were male and had an academic affiliation. The percentage of males that made up the various OR teams ranged from none to 100%, averaging 38.1%. The department with the highest number of observed surgeries was General Surgery, followed by Neurosurgery and Cardiothoracic; Vascular and Orthopedics had the fewest surgeries.

Behaviors within the cooperation category were observed most frequently (59.0% of all communications), whereas conflicts were rare (2.8%) (Table 2). All other behaviors from the OR ethogram were classified as neither (38.2%). Conflicts occurred within 69 of the 200 procedures observed (34.5%), the majority of which were low-level (i.e., interrupting; acting curt), with only 2% of the procedures featuring the highest level of conflict (i.e., throwing equipment; a violent outburst).

Attending Surgeon. Neither the age nor the gender of the attending surgeon (as a stand-alone effect) had a statistically significant effect in the comprehensive models for cooperation or conflict ($P > 0.05$) (Table S2 gives overall outcomes of both GzMLM models). When considered separately (outside the comprehensive model), however, faculty membership of the attending surgeon was associated with more cooperative communications, such as teaching (53.1% of observed nonfaculty communications versus 61.0% of observed faculty communications; odds ratio = 1.38). Although the literature mentions the surgeon's gender as affecting volubility (14), this effect could not be confirmed because both male and female attending surgeons expressed themselves at similar average rates.

Other Clinical Roles and Hierarchy. The source and the recipient of each communication were recorded for five source (actor) roles and six recipient roles (including "all" when the whole room was addressed). A comprehensive model was run, one each for percentage of cooperation and conflict, including each source and recipient and the interaction between them to see if source or recipient were predictive of the observed rates of cooperation or conflict. See Table 2 for data by source and recipient and Fig. S1 for the same by dyadic role combination.

Cooperation. The most frequent source for all communications was the attending surgeon (46.3%), with the surgical fellow/resident as the most frequent recipient (31.5%). When only cooperative communications are considered, the attending surgeon was again the most frequent source (54.1%), with the surgical fellow/resident as the most frequent recipient (41.7%) (Table 2). In the comprehensive model for cooperation, both source ($P < 0.001$) and recipient ($P < 0.001$) as well as the dyadic interaction

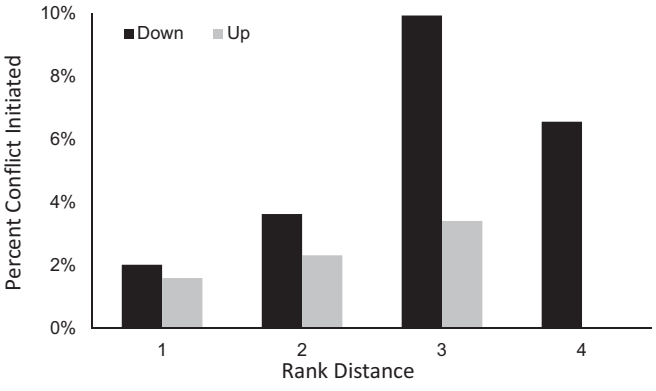

Fig. 1. Initiated interpersonal conflicts as percent of all communications up or down the social hierarchy in the OR. The hierarchy has been set as attending surgeon > surgical fellow/resident > anesthesia provider > circulating nurse > scrub person. The bars give the overall unadjusted data (conflict as percent of all communications) for individuals one to four rank positions apart in the role hierarchy. Black bars show conflict directed at individuals ranking below the source; gray bars show conflict directed at higher-ranking individuals.

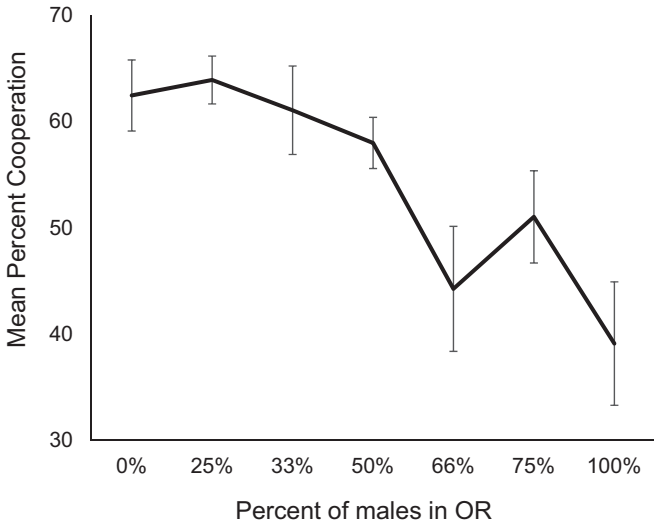

Fig. 2. Mean (± SE) overall cooperative behavior as a percentage of all communications in the OR by gender composition of the team.

between source and recipient ($P < 0.001$) were significant predictors of cooperation (Table S2).

Longer elapsed times were significantly associated with lower levels of observed cooperative behaviors (odds ratio = 0.953, $P = 0.013$); the odds of observing cooperative behavior declined by 4.9% for every additional 10 min elapsed during the surgery.

Conflict. With regards to conflict communications, the attending surgeon was still the most frequent source (67.4%), but now the circulating nurse was the most frequent recipient (26.3%) with the surgical fellow/resident ranking second (20.6%) (Table 2). Fig. S1 illustrates the high rates of conflict in these two role combinations as well as between the surgical resident and the anesthesia provider.

In the comprehensive model for conflict, the interaction between source and recipient was also significant ($P = 0.047$). One explanation of this effect may be the divergent positions occupied in the social hierarchy, which we explore in Fig. 1 by ranking the individuals in various professional roles from high to low [attending surgeons > surgical fellow/resident > anesthesia provider (often an assistant) > circulating nurse > scrub person]. An analysis of unadjusted raw data revealed that conflict initiations were mostly directed down the hierarchy (i.e., 79.9% of the 154 interpersonal conflicts observed). Expressed as percentage of communications, conflicts mainly targeted individuals several ranks apart in the role hierarchy.

Surgical Departments. Departments differed in their amounts of cooperative communications, with Gynecology having the highest at 66.6% and Orthopedics having the lowest at 49.4%. The stand-alone model for department effect on cooperation showed $F(7,177) = 3.45$, $P = 0.002$. No significant differences were seen for the rate of conflict [$F(7,208) = 1.88$, $P = 0.075$]. Fig. S2 shows the percentage interactions that are either cooperative or conflict by surgical department, ordering the departments on each measure separately. Thus, Gynecology had the highest percentage of cooperation and the lowest percentage of conflict. By contrast, Cardiothoracic had the highest percentage of conflict, at 4.5%. An exception to the generally negative relation between the two measures was Orthopedics, which ranked low on both the percentage of cooperation and the percentage of conflict.

Gender Composition of the Team. There existed significant differences among departments in the gender composition of OR teams. Neurosurgery and Cardiothoracic had higher percentages of attending male surgeons (both over 95%); Gynecology had the lowest percentage (55.6%). In roles other than the attending surgeon, Orthopedics and Neurosurgery had the highest percentage of males in the room (both averaged >50%) with Gynecology having the lowest (18.9%).

The probability of cooperation was reduced with an increasing percentage of males in the room, as illustrated in Fig. 2, which shows relatively less cooperative communication when more than half the persons in the room (excluding the attending surgeon) were male. We used this empirical drop-off point to explore the influence of both the gender of the attending surgeon and the remaining gender composition of the team (with the percentage of males in the OR split by coding 0 for <50% percent and 1 for ≥50%). Models were run for each of these gender effects and their interaction in the comprehensive models for cooperation or conflict.

For cooperation, there was a significant interaction effect between the attending surgeon's gender and the percentage of males in room ($P = 0.024$) but not for conflict ($P = 0.099$) (Table S2). If the attending surgeon's gender differed from the primary gender makeup of the rest of the surgical team, cooperation was higher, and conflict was lower. Conversely, when the gender of the attending surgeon and the predominant gender makeup of the room were alike, cooperation was lower, and conflict was higher. This effect seemed stronger for male than for female surgeons (Fig. 3).

Regarding conflict, any interaction effect appeared to apply only to male attending surgeons. Among all contexts, the average percentage of conflict was lowest (1.16%) when a male surgeon was with <50% males in the room and highest (4.01%) when he was with ≥50% males in the room. Given how rare conflicts are, we decided to look at this particular effect in an entirely different way. Instead of expressing conflict as percentage of communications, we used a binary outcome measure based on whether a given procedure was marked by at least one conflict or none at all. For this, we divided all procedures with a male attending surgeon according to the gender composition of the rest of the room. This analysis showed conflict during 50.6% of 79 procedures by male surgeons with mostly male teams but during only 21.3% of 75 procedures of male

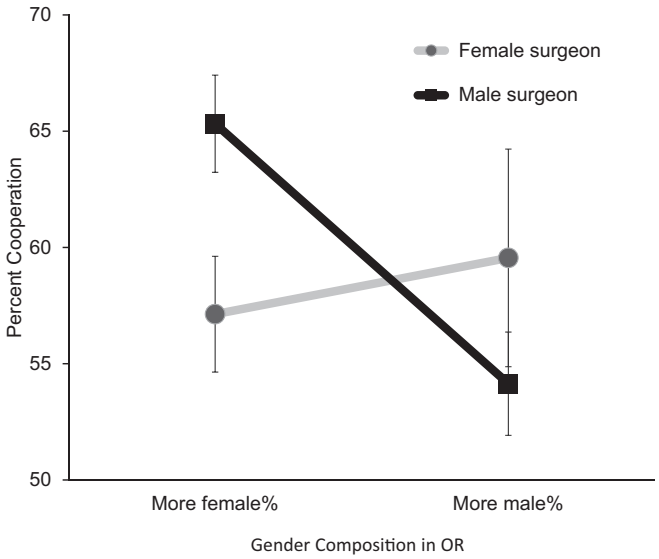

Fig. 3. The gender interaction for cooperation illustrated with unadjusted aggregated data at the surgery level for all 200 surgeries. The graph compares the mean (± SD) percentage of cooperation in the OR by attending surgeon's gender and the gender of his or her male- or female-prevalent OR team.

surgeons with mostly female teams. In other words, male/mostly male surgeon/team combinations had double the chance of at least one conflict as male/mostly female combinations (χ^2 with Yates correction = 13.04, df = 1, $P < 0.001$, two-tailed).

Nature of Conflicts. Conflicts in the OR are regularly reported in print media, although there is sparse mention of them in the academic literature. For instance, a 2011 report in *The Washington Post* recounted a situation alleging that a surgeon was so displeased with an instrument handed to her by a technician that she slammed the instrument down, breaking the technician's finger. The surgeon was suspended and ordered to attend anger management sessions (25). In 2017, *The Bismarck Tribune* reported that an oral surgeon was suspended for unprofessional conduct, including "screaming profanities" at OR clinicians (26). Despite these reports, we found conflicts meeting our definition to be infrequent at the hospitals in this study. Their intensity, however, was sometimes worrisome. Table S3 illustrates three recorded incidents with the potential of being detrimental to teambuilding as well as potentially threatening patient safety.

Discussion

As predicted, the tendency toward cooperation and conflict in the OR were partly determined by social role, with a significant source × recipient interaction in both models. Attending surgeons initiated by far most communications in general, including most conflicts. Four out of five conflicts in the OR were directed down the hierarchy and mostly against recipients several positions below the initiator. Even though conflict was rare, it was distracting and potentially detrimental to outcomes (5, 12).

Conflicts were more common when more males were present on the OR team relative to females, which is as expected given that boisterous behavior is more typical of the male gender. Some heavily male-prevalent departments (e.g., Cardiothoracic and Neurosurgery) exhibited more cooperation, as defined in the OR ethogram, than others (e.g., Orthopedics), perhaps indicating that cooperation manifests itself differently depending on the complexity of surgeries.

One independent effect in this study, however, was not attributable to one gender or the other but concerned the interaction between both. As noted in the Introduction, competition typically occurs within genders. This has been confirmed by experiments that report increased rivalry among same-gender partners in the ultimatum game, commonly played to evaluate players' senses of leverage and fairness. There is more "chivalry" and "solidarity" between partners of opposite gender playing the game (27). In this light, it is interesting that in our study cooperation increased significantly when the attending surgeon's gender differed from the gender of the majority of the remaining clinicians in the room.

Although the gender of the attending surgeon had remarkably little independent effect on behavior in the OR, the highest percentage of cooperation was observed when the attending surgeon was female in a male-prevalent room or male in a female-prevalent room. This effect seemed more pronounced for male surgeons. Moreover, the rate of conflict differed depending on the gender composition of the room, with the chance of at least one conflict during a procedure being twice as high if a male surgeon worked with mostly men compared with mostly women. These results are in line with the prevalence of intrasexual competition in primate groups and the greater need for individuals in the alpha role to assert their position vis-à-vis their own rather than the other gender. Our results also lend support to the suggestion that gender diversity may increase cooperation in the OR and other settings (28), especially in combination with cultural norms of politeness and chivalry between the genders.

Analyses by surgical department revealed discrepancies that could be interpreted according to principles proposed by Gottman for interpersonal relationships (7). He observed that there is a healthy balance between conflict and cooperation, as also found in some nonhuman primate studies (8), thus implying that the goal of OR teams should not necessarily be the elimination of conflict but its containment. According to our study, one factor that may increase the risk of tensions, and should therefore be taken into future consideration, is the length of the procedure. Longer surgeries increased the odds of conflict and reduced cooperative behavior, indicating an increase in stress and strife among OR team members.

Few interprofessional social communications were observed involving anesthesia providers, who have been described elsewhere as "unique" or "intermediate" figures in the OR hierarchy (29). At the midpoint, in terms of volubility, were the circulating nurses and scrub persons, who were the recipients of the most conflict-provoking behaviors. Our data show that OR teams are indeed hierarchical and divided by role (29, 30), problematizing some healthcare strategists' proposals to emulate the egalitarian approach advocated for high-reliability organizations (HROs) (31, 32).

A potential shortcoming of the present study was the observers' inability to continuously calculate the gender composition in the OR. We were surprised by the frequency of handoffs during a case and could not quantify everyone's attendance. As previously noted, team membership in the OR is intermittent and ad hoc at best (33). The constant shifting of clinicians challenges the assumption that "a team" exists as an entity and complicates the establishment of familiarity and the formation of shared goals (34–39). A common mindset is essential to peak performance according to teamwork literature emanating from medicine and HROs (33, 40–42) and anthropological literature describing cooperation in egalitarian societies (43). Despite these challenges, the present study features an observational methodology that may offer a more accurate picture of the social dynamics in the OR than the typical post hoc questionnaire methods. Rather than focusing on the technical side of teamwork in the room, there is a pronounced social side related to human psychology and our long evolution as social primates that we will need to keep in mind while recommending rules of engagement to enhance the level of cooperation in the OR.

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