Negotiation between parents over care:
reversible compensation during incubation

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Summary

Parental care is often beneficial for the young, but costly for the care-giving parent. Since both parents benefit from care via the offspring, whereas they pay the costs individually, a conflict is expected about how much care each parent should provide. How do parents settle this conflict? We addressed this question by reducing nest temperatures during incubation in the Kentish plover *Charadrius alexandrinus*, a small ground-nesting shorebird in which the parents share incubation. By cooling the clutch using a remote-controlled device built under the nest we experimentally increased the workload of either the male or the female in random order, and recorded the behavioral responses of the targeted parent and its mate. Unlike most previous manipulations of parental effort, our manipulation sought to measure a parent’s response to an increase, not a shortfall, in the partner’s contribution. The manipulation was also short-term and reversed between the members of a given pair. We found that there is a trade-off between the efforts of parents, since increased (or reduced) effort by the targeted parent was associated with decreased (or increased) effort by their mate, respectively. This result is consistent with theoretical models that predict compensation as a response to changed parental effort of the mate. We also found that compensation was consistent between treatments when the male or the female of a given pair was targeted. Furthermore, our results support the notion that parents adjust their effort in response to their mate’s behavior in real time, i.e. they negotiate parental roles.

Keywords: sexual conflict, parental care, precocial bird, wader, shorebird

Short title: Parental negotiation during incubation
Introduction

Biparental care of young is an excellent model system for investigating cooperation and conflict between unrelated individuals. On the one hand, cooperation between parents is beneficial, since provisioning the eggs and young with nutrients, defending them from predators and training them in useful skills usually improve the offspring’s chances of survival and reproduction (Clutton-Brock 1991, Balshine et al. 2002). On the other hand, parental care is costly since it takes time and energy, and the caring parent may be taken by predators (Lessells 1999, Houston et al. 2005). Finding the outcome of these conflicting selective forces is not straightforward, because the benefits are shared between the parents, i.e. via the offspring, whereas each parent pays the costs itself. The existence of biparental care in insects, fishes, frogs, birds and mammals thus provides excellent opportunities to test hypotheses about how conflict and cooperation influence social behavior (Trivers 1972, Parker et al. 2002).

How do parents settle their conflict? The influential model by Houston & Davies (1985) used provisioning rates of parents and predicted partial compensation; that is, if one parent increases its effort, the other parent should decrease its effort by a lesser extent. However, in Houston & Davies (1985) parents do not adjust their work rate in response to the behavior of their mate in real time, but their strategy is fixed in evolutionary time (a ‘sealed bid’ in game theoretic terminology). Models that incorporate repeated decisions of the parents (‘negotiation’) predict either compensation (McNamara et al. 1999), or responses ranging from compensation to matching, i.e. an increase in work rate in response to an increase by the mate (Taylor & Day 2004, Johnston & Hinde 2006).
Numerous experiments have been carried out to test the predictions of such models, in birds, insects, fish and mammals. Two major approaches have been used to test the responses of parents to changed effort by their mate: (i) mate removal (e.g. Erckmann 1983, Martin & Cooke 1987, Alatalo et al. 1988, Markman et al. 1996, Smiseth & Amundsen 2000), and (ii) handicapping (attaching extra weights or clipping feathers, e.g. Wright & Cuthill, 1989, Slagsvold & Lifjeld 1990, Markman et al. 1995, Sanz et al. 2000). The results of these experiments have been contradictory, since parents responded variously to the changed work rate of their mate by compensation or matching, whereas in some studies no significant response was detected (reviewed by Bart & Tornes 1989, Sanz et al. 2000, Smiseth et al. 2005, Houston et al. 2005, Hinde 2006). These experiments, however, are limited in what can be deduced about the negotiation process (if one exists), in that the manipulation usually lasted over several days of the care period, and in each pair only a single parent was manipulated.

Here we investigate the responses of parents to changed effort by their partner in a small shorebird (body mass: 40-44 g), the Kentish plover *Charadrius alexandrinus*, in which the parents share incubation. The sexes have different incubation patterns: the males incubate mostly during the night whereas females do most of the daylight incubation (Rittinghaus 1961, Fraga & Amat 1996, Kosztolányi & Székely 2002). After hatching of the chicks one parent (usually the female) may desert the brood, thus brood care is variable in most populations: biparental, male-only and female-only care may all occur in a single population (Lessells 1984, Warriner et al. 1986, Amat et al. 1999, Kosztolányi et al. 2006).

To manipulate incubation effort in the Kentish plover we increased the workload of parents by cooling the nest and the eggs using a remotely controlled device. Our
experience is novel for two reasons. First, we used short-term manipulations (hours)
whereas previous studies of parental interactions employed long-lasting manipulations
(days, weeks; by removing the mate, or attaching extra weights or clipping feathers).
The advantage of our approach is that we can separate effects during and after
manipulations. Second, males and females of each pair were manipulated on different
days in random order, i.e. we reversed the manipulations between members of a given
pair. This has not been done in previous studies, except Hinde (2006) used playback of
begging calls to reversibly manipulate care by male and female great tits *Parus major*.

We had two major objectives. First, to test how parents respond to an increased
workload during incubation. Second, to test how males and females respond to a
changed level of parental effort of their mate. Unlike most avian studies of parental
effort, (i) we manipulated the parental behavior during incubation and not during brood
care, and (ii) we aimed to increase and not decrease the effort of the manipulated parent.
During incubation the costs of parental absence, and thus the joint commitment to care,
may differ from during chick feeding (e.g. prolonged absence may lead to embryo death
rather than retarded growth). An advantage of targeting incubation is that offspring
behavior during incubation is unlikely to confound the outcome of the negotiation
between the parents (Parker et al. 2002, Johnstone & Hinde 2006), since in behavioral
(though not evolutionary) terms an egg is a more passive player in the game than a
chick. A further difference between brood care and incubation in the context of parental
care is that during brood care the parents can independently increase the contribution to
chick feeding, whereas during incubation an increase in incubation time by one parent is
only possible if the other member of the pair is not sitting on, or can be persuaded to
leave, the nest.
Material and methods

Study area and field methods

The experiment was carried out at Al Wathba Wetland Reserve (24º 15.5’ N, 54º 36.2’ E) in the United Arab Emirates about 40 km south-east from Abu Dhabi, in two years: 2005 (23 March – 19 June) and 2006 (26 April – 12 July). The Reserve is 3.7 km long and 1.9 km wide, the total area is about 450 ha, and it is composed of natural and man-made water bodies with sand dunes separating the water bays of the lakes.

To study incubation behavior and manipulate the thermal condition of the nest an automatic nest monitoring system was developed (Figure 1). The system consisted of four main parts. First, an electronic balance (Navigator, Ohaus Corporation, Pine Brook, New Jersey, USA) was placed under the nest scrape and connected to a data logger (Gigalog, Audon Electronics, Nottingham, UK) to record the body mass of the incubating parent every 20 s. The nest was placed on a plastic tray on top of the balance. The extreme ambient temperature (see below) and strong wind, however, made the readings of the balance unreliable, so these measurements were not investigated further.

Second, a thermo-probe was inserted into the bottom of the nest scrape, and another probe about 25 cm from the nest scrape at ground level to measure the thermal condition of the nest and the environment, respectively. The probes were connected to a data logger (Tinytag, Gemini Data Loggers Ltd., Chichester, UK) that recorded data every 20 s. Third, a small spy camera (Outdoorcam, Swann Communications Pty. Ltd., Richmond, Victoria, Australia) was positioned about 1 m from the nest and connected to a digital video recorder (MemoCam, Video Domain Technologies Ltd., Petah Tikva, Israel) to record the behavior of the parents every 20 s. The camera had infrared light
sources that allowed recording of behavior at night. The plumage of adult Kentish plovers is sexually dimorphic during the breeding season and this allows identification of sexes from the photos. Fourth, a Peltier heat pump (RS Components Ltd., Corby, UK) was placed under the nest scrape to change the thermal condition of the nest. This device was connected to a central unit that was remote controlled. The power was supplied by a car battery. All parts of the system (except the camera) and the cables were hidden underground to minimize the disturbance to the plovers.

The experiment lasted for four days at each nest. Before the experiment both parents were captured, measured and color ringed. All experimental nests had three eggs (modal clutch size), and the clutches were 11.9 ± 1.02 (mean ± SE, n = 20) days old at the start of the experiment. On the first day the system was set up at the nest, the second day was a baseline, and on the third and fourth days we cooled the nest between either 22:00 – 04:00 or 05:00 – 09:00 to target the male or female, respectively (Figure 2). The order of cooling was randomized at a nest. The system was visited daily to change memory cards in data loggers, to change the battery (every 2nd day), and to check the system for proper operation. The mean length of these visits were 20.1 ± 0.56 min (mean ± SE, n = 20), and data from these periods were excluded from the analyses. No visit was made during the manipulations (i.e. during cooling).

Data were collected by two nest monitoring systems at 20 nests in total. Three nests were predated while the experiment was running, therefore data are missing for three female manipulation days. At three different nests the parents delayed returning to the nest after setting up the system; at these nests an extra baseline day was taken, and data from the first baseline day were omitted.

We expected that the parents aim to mitigate the effect of cooling on egg
temperatures. To assess the effect of cooling on nest temperature without the parents, we measured nest and ambient temperatures at five unused nests (‘dummy nests’ henceforward; three nests in 2005 and two in 2006). In these cases the nest monitoring system was set up at previously predated, abandoned or hatched Kentish plover nests for one day, and three fresh eggs of Japanese quail *Coturnix japonica* were cooled for equivalent periods for the male and female manipulation (22:00 – 04:00 or 05:00 – 09:00, respectively). The quail egg is similar in size and shape to the Kentish plover egg.

**Statistical analyses**

We considered each nest as the unit of analysis. The effect of manipulation on incubation behavior was measured by the change in incubation time (%, i.e. percentage of incubation during manipulation day minus percentage of incubation during baseline day). The baseline and manipulation days were divided into two parts: manipulation period (22:00 – 04:00 and 05:00 – 09:00 for male and female manipulation day, respectively), and after manipulation period (04:00 – 10:00 and 09:00 – 13:00 for male and female manipulation day, respectively). The responses by the male and female during and after manipulation were not influenced significantly by year, by the nest monitoring system (set one or set two) used for data collection and manipulation, or by the order of manipulation (ANOVAs, $p \geq 0.194$ in all cases), therefore these effects were not considered in further analyses.

With the 22:00 – 04:00 manipulation period we targeted the male, whereas with the 05:00 – 09:00 period the female parent was targeted. However, the targeted parent did not always incubate during the whole cooling period (see below); thus the amount of
manipulation experienced by a given parent depended on the time it spent on the nest during manipulation. Therefore, we used a covariate (\(\Delta T\)) in the linear models to investigate the effect of manipulation on the response of the sexes. \(\Delta T\) for a given sex was defined as the absolute value of the effect of cooling on nest temperature (\(T_{\text{nest}} - T_{\text{ambient}}\)) multiplied by the time the parent was incubating the nest during the cooling period. The effect of cooling for a given day of the season was estimated by using the temperature data of dummy nests (see below).

The presence of parents influenced the effect of cooling because the difference between nest and ambient temperature (\(T_{\text{nest}} - T_{\text{ambient}}\)) was smaller at experimental nests than at dummy nests (22:00 – 04:00, experimental nests: -1.2 ± 0.27 °C, dummy nests: -4.2 ± 0.52 °C; t-test, \(t_{23} = 4.924, p < 0.001\); 05:00 – 09:00, experimental nests: -3.3 ± 0.25 °C, dummy nests: -5.9 ± 0.32 °C; \(t_{20} = 5.245, p < 0.001\)). Furthermore, the effect of cooling (i.e. \(T_{\text{nest}} - T_{\text{ambient}}\)) at dummy nests tended to be larger in absolute value over the breeding season (least-squares regressions, male manipulation: \(B = -0.02 ± 0.021\); \(t_3 = 1.157, p = 0.331\); female manipulation: \(B = -0.02 ± 0.007\); \(t_3 = 3.552, p = 0.038\)). Therefore, the manipulations received by the sexes (\(\Delta T_{\text{sex}}\)) were estimated using temperature difference (\(T_{\text{nest}} - T_{\text{ambient}}\)) estimated for a given date using the coefficients of the above least-squares regressions.

During male-targeted manipulations the male was on the nest 70.2 ± 5.06% of the time (mean ± SE), the female 26.2 ± 4.71%, and neither parent 3.6 ± 0.71%. That is, males spent more time on the nest than females when males were targeted (paired t-test, \(t_{19} = 4.522, p < 0.001\)). In contrast, during female-targeted manipulations the females spent more time on the nest than males (\(t_{16} = 11.525, p < 0.001\); male: 9.1 ± 2.84%, female: 77.3 ± 3.41%, neither: 13.6 ± 2.10%). Thus, during male-targeted manipulations
the males experienced more cooling than females ($\Delta T_{\text{male}} = 17.5 \pm 1.34 \, ^\circ\text{C} \times \text{h}$, 

$\Delta T_{\text{female}} = 6.8 \pm 1.28 \, ^\circ\text{C} \times \text{h};$ paired t-test, $t_{19} = 4.321, p < 0.001$), whereas during female-targeted manipulations females experienced more cooling than males

($\Delta T_{\text{male}} = 2.1 \pm 0.69 \, ^\circ\text{C} \times \text{h}, \Delta T_{\text{female}} = 18.2 \pm 0.94 \, ^\circ\text{C} \times \text{h}; t_{16} = 10.694, p < 0.001$). This is, of course, what the experiment was designed to achieve, but we stress that ‘male’ and ‘female’ targeting was a statistical, not deterministic, difference because sometimes the ‘wrong’ sex was present and experienced the manipulation targeted at its mate.

One may argue that the responses of parents may depend on their original effort; for instance, if a parent is already incubating 90% of its time, it is less likely to increase its incubation as a response to manipulation than a parent that incubates only 10% of its time (a ‘ceiling effect’). We investigated this proposition by weighting the response as

$\exp(x/100)$ when $x$, i.e. the change in incubation time was a positive response, and

$\exp(1-x/100)$ when $x$ was negative. However, applying weights does not change our conclusions, so these results are not reported.

We used vectors to analyze the responses of parents to their mate’s behavior. The baseline period was taken as the origin, and the coordinates represented changes in male and female incubation compared to the baseline period. Thus, a vector captured the joint change in the level of incubation of the male and female in a given pair. In one pair incubation did not change during the male manipulation period compared to the baseline (i.e. the length of the vector was zero), therefore this nest was not considered during the male manipulation period.

To investigate the distribution of vectors, we divided the parameter space into two triangles along the male change = female change (+1 slope) line (isocline, henceforward). Vectors between 0º and 45º either side of the isocline mean that both
parents increased incubation (‘matching’, see Figure 3), vectors between 45º and 135º mean that one parent increased incubation while the other decreased (‘compensation’ by the female or the male; upper left and lower right triangles, respectively), whereas vectors between 135º and 180º mean that both parents decreased incubation (‘negative matching’).

We investigated the behavioral responses in vector space in three ways. First, we used the absolute deviation of vectors from the isocline, and calculated the mean deviation and their 95% confidence intervals (95% CI). Second, we also considered the length of the vectors and calculated the mean vector and the 95% confidence area for the altered level of incubation separately for the two triangles. Finally, to compare the responses of pairs between male and female manipulations we used the absolute deviation of vectors from the isocline.

Statistical analyses were carried out using R 2.6.0 (R Development Core Team 2007). Values are given as mean ± SE unless indicated otherwise.

Results

Effect of manipulation on incubation behavior

Cooling of the eggs influenced parental behavior: total incubation was higher during male manipulation than during baseline periods, and total incubation increased with the cooling the parents experienced (Table 1). Males, but not females, increased their incubation time with the manipulation they received (regression on $\Delta T$). After manipulation, male incubation non-significantly tended to decrease, whereas female incubation increased compared to the baseline day (Table 1). Similar to the preceding
results, total incubation was higher during female manipulation than during baseline (Table 1). Furthermore, incubation by females, but not males, was higher during the manipulation than baseline (Table 1). After female manipulation, total incubation was significantly higher in nests that had previously received more cooling (regression on \( \Delta T \)), but no other relationships after female manipulation were significant (Table 1). The non-significant trend was for females to decrease incubation, and for males to increase, after female manipulation.

Whilst these results show that the manipulation had an effect on parental behavior, they cannot explain how a parent responded to the changed effort of its mate, because here males and females were tested independently. Furthermore, the slopes on \( \Delta T \) are not comparable between the sexes because the ranges of the explanatory variable (i.e. the amount of manipulation received) were different between males and females (see Methods for the mean \( \Delta T \) received by the sexes).

**Response to mate’s behavior**

Compensation by the mate, rather than matching, was the most common response to the manipulation. Firstly, during male manipulations the mean angle of vectors from the isocline and their 95% confidence interval fell into the compensation area (mean: 68.3°, 95% CI: 57.0° – 79.6°, \( n = 19 \)). Similarly, the mean vectors and their confidence areas were restricted (upper left triangle) or almost restricted (lower right triangle) to the compensation areas (Figure 3). Unexpectedly, in nine out of 19 nests, the female increased her incubation (and the male showed compensatory decrease) when the male was the intended target. We investigated why this might have happened. It turned out that at these nine nests the females experienced significantly more cooling.
\( \Delta T_{\text{prop}} = \Delta T_{\text{female}} \times (\Delta T_{\text{male}} + \Delta T_{\text{female}})^\dagger = 0.41 \pm 0.060), \) than at the other ten nests

\( \Delta T_{\text{prop}} = 0.18 \pm 0.063; \) t-test, \( t_{17} = 2.579, p = 0.019). \)

Secondly, the effects of female manipulations were consistent with that of the male manipulations (mean angle: 70.2°, 95% CI: 56.8° – 83.7°, \( n = 17 \)), and the mean vectors and their confidence areas were nearly always in the compensation areas (Figure 3).

Thirdly, after manipulations the responses of the parents with respect to each other were similar to the ones during manipulations, because the mean angle of vectors were inside the compensation areas (male manipulation, mean: 85.7°, 95% CI: 64.9° – 106.5°, \( n = 20 \); female manipulation, mean: 90.4°, 95% CI: 76.9° – 103.9°, \( n = 17 \)).

Furthermore, both the mean vectors and their confidence areas were largely restricted to the compensation areas (Figure 3).

It is unlikely that the compensatory responses were due to an upper limit in total incubation, because the percentage of time the two parents spent on the nest was significantly different from 100% during the manipulation and after manipulation periods on both manipulation days (during male manipulation: 96.4 ± 0.71%, \( t_{19} = 5.052, p < 0.001 \); after male manipulation: 85.5 ± 1.68%, \( t_{19} = 8.626, p < 0.001 \); during female manipulation: 86.4 ± 2.10%, \( t_{16} = 6.471, p < 0.001 \); after female manipulation: 94.0 ± 1.99%, \( t_{16} = 3.039, p = 0.008 \), see also Methods for a summary of ceiling effect analyses).

Consistency of responses

Finally, the responses of parents were highly consistent between male and female manipulations (Figure 4, \( n = 13 \) pairs out of 16 were in, or on the border of, the compensation area, i.e. within 25% of the whole parameter space; binomial test using
Discussion

Our experiment provided three key results. First, Kentish plover parents responded to the changed level of incubation of their partner in real time, a result consistent with negotiating parental roles (*sensu* McNamara et al. 1999). Thus our results of the manipulation of parental workload during incubation are in line with the results of most experimental manipulations of parental effort during brood rearing of birds. Most studies have also found real-time responses to the change in parental effort by the mate (e.g. Wright & Cuthill 1989, Markman et al. 1995, Sanz et al. 2000), whereas few have supported the ‘sealed bid’ notion (Schwagmeyer et al. 2002 and references therein). The reason for these intriguing interspecific differences in negotiation strategies remains unknown.

Second, we showed that compensation, rather than matching, was the most common response by Kentish plover parents to cooling of the eggs (or the partner’s response to cooling). That is, our results are in line with theoretical models that predict compensation between parents (McNamara et al. 1999, Johnstone & Hinde 2006). Unlike most previous experimental manipulations of parental effort, our manipulations aimed at increasing the contribution of the targeted parents (*cf.* handicapping and removal), and we did achieve this because total incubation increased during both manipulation periods compared to the baseline day. When one parent increased its incubation time in response to egg cooling, the response of the partner was usually not to keep its own effort constant, or match it, but to decrease it. The latter result suggests that there is a conflict between the parents over the amount of parental effort, and that
each parent tries to avoid the costs of parental care and shunt the work on its partner (Houston et al. 2005). Some of our results indicate overcompensation (e.g. increasing total incubation). These results are intriguing because they are not in line with the results of most previous experiments and the predictions of theoretical models. However, our results are not comparable to previous studies because we aimed at increasing the effort of the manipulated parents.

Third, the parents’ responses were consistent during the manipulation and after manipulation periods, since most pairs exhibited compensation during all four periods. This consistency strengthens the suggestion that the actual changes in parental effort are results of a negotiation process.

To our knowledge, the only experimental study on parental effort that, similarly to our study, has aimed at increasing the contribution of the targeted parent was Hinde (2006). Using playback of begging calls to modulate feeding rates in great tit, she showed matching rather than compensation between parents. The reason for these contrasting results may lie in the differences in information available for the parents, since the information the parents have on the need or value of offspring may profoundly influence whether compensation or matching is the outcome of the negotiation process (Johnstone & Hinde 2006). Our results are in line with the predictions of Johnstone & Hinde (2006), because compensation is expected if the parents have reliable and symmetric information about the need of the offspring, which in the Kentish plover may be the difference between the optimal and actual egg temperature. In contrast, in Hinde (2006) the great tit parents may have used the mate’s increased work rate as a cue of increased brood need or quality, and they responded by matching, as predicted by Johnstone & Hinde (2006) if the parents have only partial information regarding brood.
need and quality.

The trade-off between male and female parental effort observed in this study has also been seen in comparative studies. Olson et al. (2008) showed, using parental care data from 193 bird species, a negative relationship between male and female care (see Thomas et al. 2007 for a similar result in shorebirds). These results are consistent with the proposition that there is an evolutionary tug-of-war between the sexes over who should care for the young and, although there is no necessary relationship between evolutionary and behavioral responses, this conflict may also be manifested during real-time behavioral decisions.

In conclusion, we have shown that parents rapidly and consistently respond to the changed effort of their mate in a ground-nesting shorebird, the Kentish plover, during incubation. We have also shown a trade-off between the parental effort by males and females (compensation). However, we do not know the limits of the compensatory response. That is, how far the pairs can be moved from their negotiated effort before failing to compensate and, for example, deserting the nest. To reveal the stability of the compensatory response, repeated manipulations of the same individuals with different levels of manipulations (e.g. variable amount of cooling) is needed.

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ABS/ASAB Guidelines for the Treatment of Animals in Behavioral Research and
Teaching.

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Figure legends

Figure 1
The system we used for monitoring and manipulating nest temperatures in the field. (a) The camera with a Kentish plover nest, (b) the electronic balance, datalogger and Tinytag temperature logger, (c) the video recorder, the main unit (controlling the Peltier device and distributing power), and the battery in a separate box about 5 m from the nest.

Figure 2
The effects of cooling on internal nest temperature (solid line) and the ambient ground temperature (broken line) at an experimental nest. In this example the first cooling targeted the male, and the second cooling the female.

Figure 3
The responses of Kentish plover parents during manipulation (left panels) and after manipulation (right panels). The thick vectors are the mean of vectors in the upper left and lower right triangles, and the shaded boxes are the 95% confidence areas for the mean vectors. The number of nests (n) is given for each triangle (see Methods).

Figure 4
Summary of parental responses. Angles are given as the absolute deviation from the isocline (see Methods). The behaviors of a pair during manipulation (●) and after manipulation (○) are connected.
Table 1
Change in incubation time (%, manipulation − baseline) in Kentish plover parents, and the effect of received manipulation ($\Delta T$, °C × h) on the change in incubation time expressed as the slope of least-squares regressions. $\Delta T_{sex}$ means manipulation received by the male, the female and by both sexes, respectively.

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<th>Change in incubation</th>
<th>Slope on $\Delta T_{sex}$</th>
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<td>Male</td>
<td>Female</td>
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<td>Male manipulation</td>
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<td>During manipulation</td>
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<tr>
<td>(22:00 – 04:00)</td>
<td>3.3 ± 4.80, $p = 0.498$</td>
<td>1.9 ± 0.71, $p = 0.014$</td>
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<td>1.9 ± 4.36, $p = 0.671$</td>
<td>1.3 ± 0.74, $p = 0.104$</td>
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<td>5.2 ± 1.79, $p = 0.009$</td>
<td>1.1 ± 0.43, $p = 0.026$</td>
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<td>After manipulation</td>
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<td>(04:00 – 10:00)</td>
<td>-5.1 ± 2.66, $p = 0.070$</td>
<td>0.5 ± 0.46, $p = 0.317$</td>
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<td>11.4 ± 4.09, $p = 0.011$</td>
<td>-1.1 ± 0.70, $p = 0.126$</td>
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<td>6.3 ± 3.67, $p = 0.100$</td>
<td>0.4 ± 1.02, $p = 0.731$</td>
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<tr>
<td>Female manipulation</td>
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<td>During manipulation</td>
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<tr>
<td>(05:00 – 09:00)</td>
<td>-4.0 ± 2.49, $p = 0.131$</td>
<td>-0.3 ± 0.93, $p = 0.723$</td>
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<td>19.3 ± 6.42, $p = 0.008$</td>
<td>2.6 ± 1.62, $p = 0.122$</td>
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<td>15.4 ± 5.74, $p = 0.017$</td>
<td>3.5 ± 1.94, $p = 0.093$</td>
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<tr>
<td>After manipulation</td>
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<td>-0.8 ± 1.26, $p = 0.514$</td>
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<td>-1.7 ± 3.06, $p = 0.584$</td>
<td>-0.4 ± 0.83, $p = 0.613$</td>
</tr>
<tr>
<td></td>
<td>-1.1 ± 1.50, $p = 0.475$</td>
<td>1.1 ± 0.48, $p = 0.037$</td>
</tr>
</tbody>
</table>

Means ± SEs, and probabilities from one-sample t-tests on the change in incubation ($df = 19$ and $df = 16$ for male and female manipulation, respectively), and on the slope of least-squares regressions ($df = 18$ and $df = 15$ for male and female manipulation, respectively) are given. Statistically significant values are in bold.