

Coherent use of information by hens observing their former dominant defeating or being defeated by a stranger

Michèle-E. Hogue ^a, Jacques P. Beaugrand ^{a, *} and Paul C. Laguë ^b

^a *Unité d'Éthométrie, Département de Psychologie, Université du Québec à Montréal, C.P. 8888, Succ. «Centre Ville», Montréal, Québec H3C 3P8, Canada.*

^b *Department of Animal Science, Macdonald Campus of McGill University, 21111 Lakeshore, Ste-Anne-de-Bellevue, Québec, H9X 3V9, Canada.*

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* Corresponding author: **Internet: beaugrand.jacques@uqam.ca**

Abstract

This study examines the role of observation during the formation of triads in female domestic hens. Results indicate that during hierarchy formation, a hen observing agonistic interactions and conflict settlement between its former dominant and a stranger uses this information when in turn confronted by the latter. Under a first condition (**E**, $N=15$ triads), bystanders witnessed their prior dominant being defeated by a stranger before being introduced to them. In a second condition (**C1**, $N=16$ triads), bystanders witnessed the victory of their prior dominant over a stranger. In a third condition (**C2**, $N=15$ triads), bystanders witnessed two strangers establishing a dominance relationship before being introduced to their prior dominant and to a stranger the former had just defeated. The behavioural strategies of bystanders depended on the issue of the conflict they had witnessed. Bystanders of the **E** condition behaved as having no chance of defeating the stranger. They never initiated an attack against it, and upon being attacked, readily submitted in turn to the stranger. On the contrary, bystanders of the **C1** condition behaved as having some chances against the stranger. They initiated attacks in 50% of cases, and won 50% of conflicts against the stranger. Under condition **C2**, bystanders first initiated contact with the strangers in only 27% of cases, which approximates the average of their chances for defeating the stranger. However, bystanders finally defeated the strangers in 40% of cases. These results suggest that bystanders of conditions **E** and **C1** gained some information on the relationship existing between their prior dominant and the stranger and that they used it coherently, perhaps through transitive inference, thus

contributing to the existence of transitive relationships within the triads. Alternate explanations are examined.

Key words: Domestic fowl; Dominance; Hierarchy formation; Observation; Transitive inference.

Introduction

Observational learning during hierarchy formation has been suggested by Altmann (1962) and Rowell (1974). Fagen (1977) implicitly relied on such a mechanism when he proposed that animals could compare each other in a group without necessarily using direct confrontation. The adaptive value of avoiding a fight is thus justified: based on ritualized behaviour or on simple observation at a distance, comparing one's chances of winning an encounter as being high or low rather than engaging in a close encounter permits an individual to avoid getting into a fight and taking the risk of being injured. One form of assessment at a distance is achieved when an individual evaluates its own potential of winning against a stranger, by seeing that stranger comparing itself to an already gauged opponent. This is the case when an individual observes its former dominant being dominated in turn by a stranger; the observer can gain from this experience by retaining the information to use it later to avoid or to submit readily to the stranger (Slater, 1986; Zayan, 1987; Cheney and Seyfarth, 1990a, b). The correct use of available information not only diminishes the risks of injury between the observer and the stranger in the short term by the economy preventing of a possibly dangerous fight, but in the long term as well. It contributes to the formation of linear triads in which all dominance relationships ($>$) are determined or complete as well as transitive (*i.e.* given that $X > Y$ and $Z > X$, $Z > Y$ must exist also). Social structures in which all dominance relationships based on agonistic behaviour satisfy transitivity stabilize early and become peaceful more rapidly (Guhl and Allee, 1944; Zayan, 1984).

Chase (1982) proposed a mechanism that could favour transitivity within triads and large hierarchies assembled from these triads by successive victories and defeats of potential members. However, to profit from successive victories or defeats, animals must meet each other in turn repeatedly as pairs as in a tournament. The existence of a cognitive mechanism based on observation could contribute to transitivity, while reducing the number of required dangerous confrontations to reach social stability. Such a complex cognitive ability could require from the animal the capacities to recognize individually the conspecifics implied in the relationship(s) and to recall the dominance relationship(s) already established between them, including those relationships in which the subject is already concerned. These two prerequisite capacities seem to exist to some extent in animals. Individual recognition has been documented in many species that form dominance orders, in shrimps (Johnson, 1977), fish (Zayan, 1974; Beaugrand and Zayan, 1985), fowl (Guhl and Ortman, 1953; Zayan, 1987), and other higher vertebrates (Colgan, 1983).

There is also growing evidence that monkeys in many different species observe interactions in which they are not involved, thus gaining knowledge of other animal's social relationships, and that such knowledge affects their future behaviour (*cf.* Cheney and Seyfarth, 1990a). A variety of observational data also suggests that monkeys recognize the dominance *ranks* of others (Cheney and Seyfarth, 1990b). Studying captive goldfinches, Popp (1987) noted competitive interactions among individuals at a feeding site that contained two feeding perches. He found that when a dominant bird flew into a site that was already monopolized by two subordinate animals, it usually approached and supplanted the lower ranking of the two, as if it recognized the birds' relative ranks.

The capacity to use this information coherently in order to anticipate conduct or choice in situations not yet realized is less documented. Such a cognitive process, which enables an individual to retain information for further use and that contributes to transitivity, is called *transitive inference*. We use this term in its deflated sense (Davis, 1992a), *i.e.* without reference to the nature of the mechanism allowing the resulting inference to be transitive. It could be logic (syllogistic reasoning) as presumed in humans (Piaget, 1967) and in some primates (McGonigle and Chalmers, 1977; Gillan, 1981). It could be *paralogic* as in rats (Davis, 1992b) or noncognitive and simply associative as in pigeons (Von Fersen et al., 1991).

Zayan (1987) has suggested that future models on the dynamics of peck-orders should include transitive inference to explain the formation of transitive relationships where all animals are not seen to interact in successive pairwise contests, as assumed in the model of a round-robin tournament, or as implied by Chase's «jigsaw puzzle» model.

We herein studied the role of observation during the formation of triads in hens. More specifically, we were looking for behavioural indices that could suggest the use of transitive inference in hens during hierarchy formation. Will a hen observing her prior dominant being defeated by a stranger use the information thus gained through observation to avoid or to submit readily to the stranger when confronted in turn by it ?

Methods

Subjects and material

We used 150 adult hens from a local flock of Red Rock x Light Sussex. They were raised in 6 separate deep litter pens (2.4 x 3.2 m) of 25 hens each. The encounters were staged in 8 cages. The cages were made of fibreglass with a front door made of aluminium bars allowing observation. These cages were disposed on 2 levels in sets of 4 (Fig. 1), each set composed of a central unit (75 x 100 x 100 cm) surrounded by 3 smaller satellite cages (70 x 75 x 75 cm). Each satellite cage was equipped with 2 interchangeable sliding doors. One was made of mesh and allowed the hen on standby in the satellite cage to see what was going on in the central unit. The second door was opaque and did not allow observation. These doors were slid open at will by the researcher, allowing the hen on standby to pass freely from the satellite cage into the central unit.

Control of variables and research outline

During the experiment, no encounters were conducted with hens coming from the same pen, but hens from different pens could be used more than once unless they had met less than 2 weeks before. According to Chase (1982), hens no longer recognize penmates after 2 weeks of separation. Handling was also kept to a minimum by having hens spontaneously pass from one compartment to another once the door was opened. One condition required more handling than the others. However, hens were very tame and used to being handled. Moreover, a period of recuperation of at least 15 min. was always imposed after handling.

The first 2 independent dyadic relationships, as well as the triadic assembly were staged in the central units. Satellite cages served for the second dyadic encounters, for isolating hens, and allowing bystanders

to watch what happened in the central units.

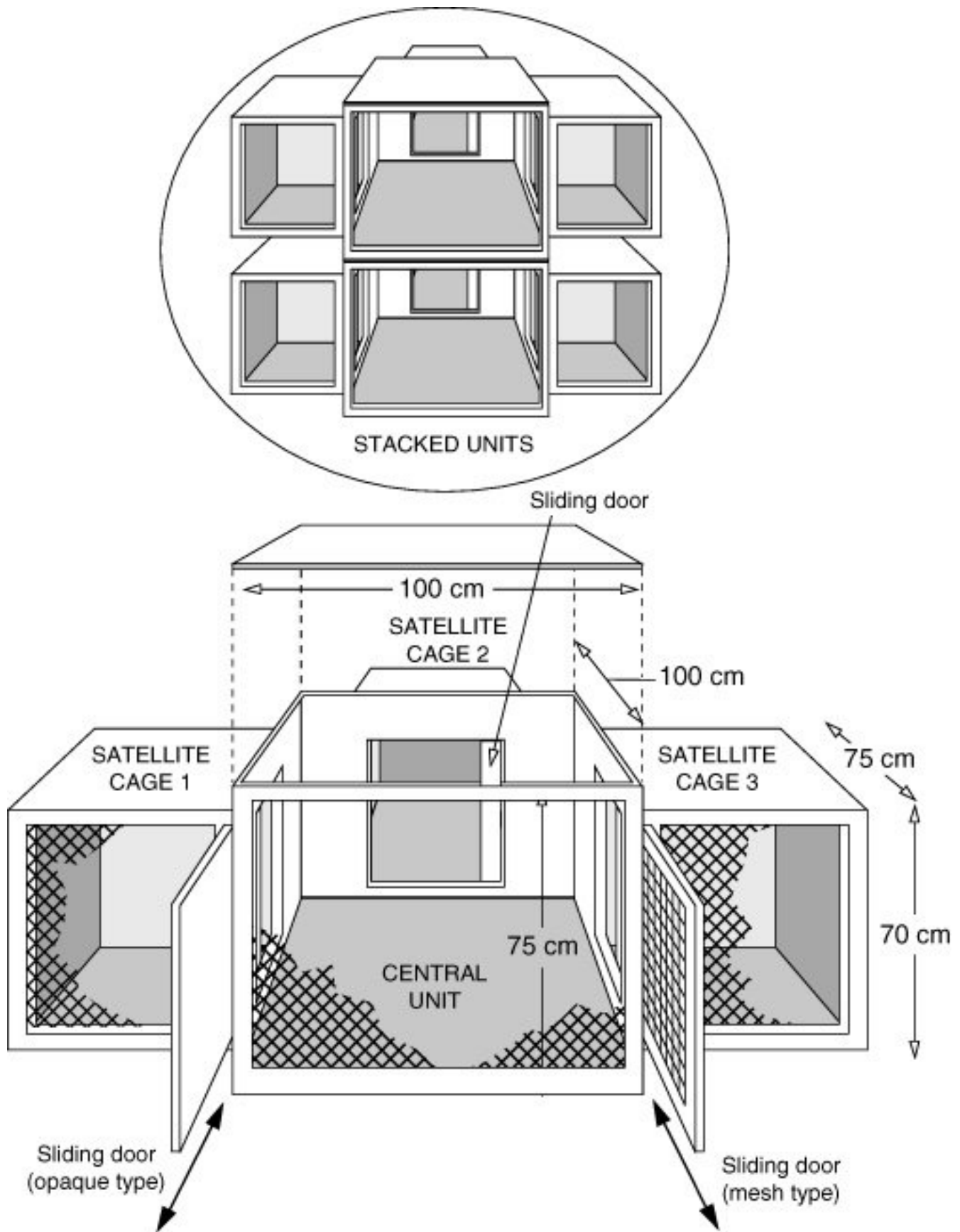


Fig. 1. Cages used to realise dyadic and triadic encounters. The cages were disposed on 2 levels in sets of 4, each set composed of a central unit surrounded by 3 smaller satellite cages.

Some studies have shown that weight and comb size (Ligon, 1990; Cloutier et al., 1996) could influence the outcome of an agonistic encounter in hens; therefore, those variables were controlled by the experimenter by choosing hens of similar weights and comb areas (with differences <10%) to encounter in dyads and triads.

Three conditions of information for bystanders were created using hens originating from the 6 available lots. Each condition corresponded to one independent sample of triads. In the experimental condition **E** ($N=15$ triads) a bystander *B*, subordinate to hen *A*, saw a stranger *C* defeating *A* before joining in turn *A* and *C*. *B* was thus presumed to be informed about *i) A>B* and *ii) C>A*. A first control condition **C1** ($N=16$) was for the direction of the dominance relationship between *A* and *C*: the bystander *B*, subordinate to *A*, saw *A* defeating *C* before joining *A* and *C*. *B* hens of condition **C1** were thus presumed to be informed about *i) A>B* and *ii) A>C* rather than *C>A* as in the **E** condition. In a second control condition **C2** ($N=15$), *B* first watched 2 strangers encountering before joining *A* and *C*. This second control condition was required to control for the mere fact that hen *B* had some knowledge of the relationship between *A* and *C*, and to control for the excitation produced by seeing 2 hens settling conflict. When in turn *B* encountered *A* and *C*, it was informed that *i) A > B*, but it was *not* informed about *ii) the nature of the dominance relationship existing between A and C*, which in all cases was that *A* had defeated *C*.

Procedures

Triads were assembled on a single day in 5 successive steps (Fig. 2). The procedure followed under conditions **E** and **C1** was rigorously the same, except that at step *IV*, *C* dominated *A* under condition **E** while *A* dominated *C* under **C1**. Condition **C2** was realized at each third day, to keep in step with the production of triads of the two other conditions.

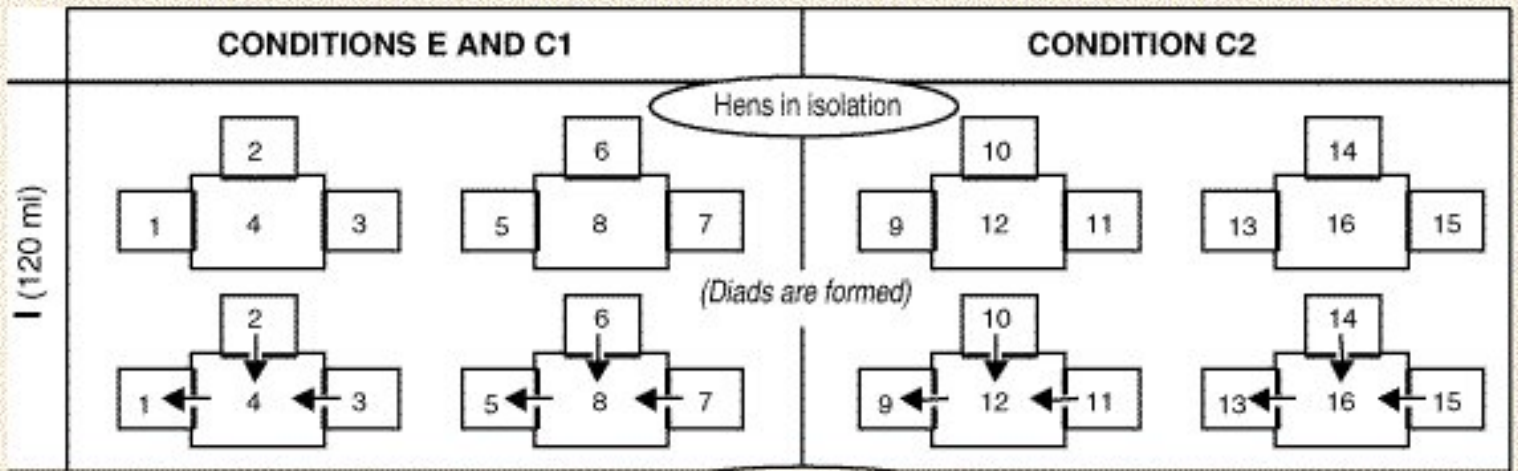
Under each condition, 8 hens were isolated at step *I* in individual cages of the setup and left there for 2 hours. At step *II*, 2 dyads were formed at each setup level with hens from that same level. By convention, we define *A* as the hen dominating ($>$) hen *B* in the central unit and *C* as the hen defeating *D* in a satellite cage of a given setup level. In particular, at the upper () level of the setup $A>B$ and $C>D$ were obtained, while at the lower () level, $A>B$ and $C>D$. *D* and *D* hens did not serve further and were returned to their respective pens after this step. Hens were left together in dyads for 90 min. Hens *A* (*i.e.* *A* and *A*) and *B* (*i.e.* *B* and *B*) were then incited to move to satellite cages and *C* (*C* and *C*) to the central unit of the same setup level. Under conditions **E** and **C1**, we passed immediately to step *III*. However, under condition **C2**, *B* and *B* hens were first interchanged by capturing them by hand and introducing *B* in the satellite cage of *B* and vice versa.

Step *III* consisted of leaving *C* hens in isolation in the central cage, allowing them to familiarize for 30 min with the place where they would meet *A*. In the meanwhile, *A* and *B* hens of conditions **E** and **C1** were kept in isolation in 2 distinct satellite cages of the same setup level. Under condition **C2**, the *A* hens remained in isolation at its proper setup level, but *B* hens came from the alternate level.

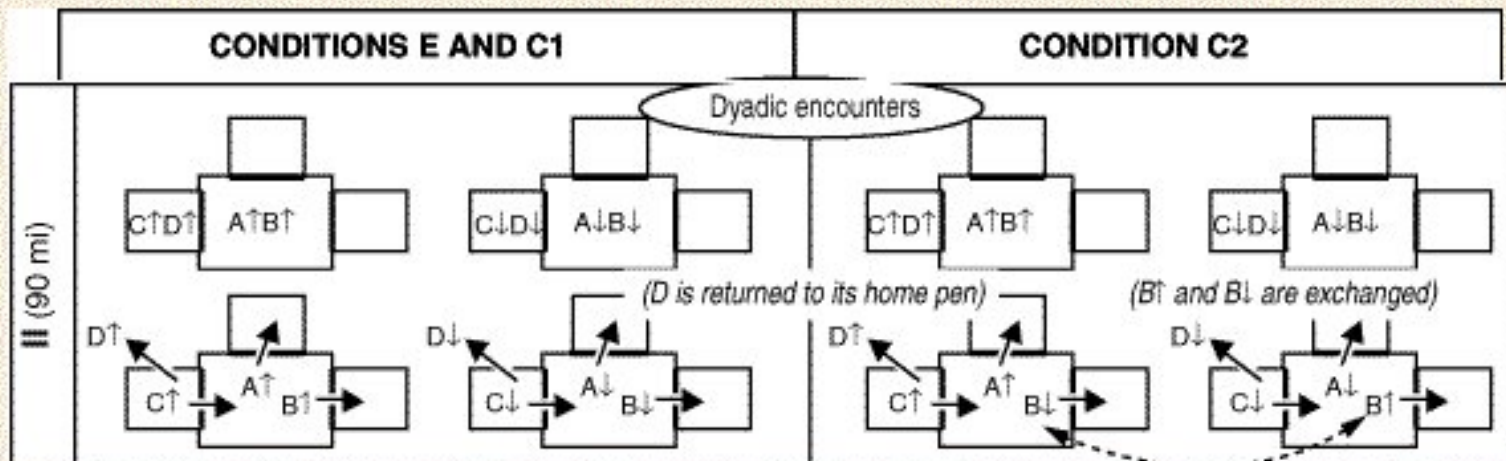
At step *IV*, the door between *A* and *C* opened, and *A* passed from its satellite cage to the central unit where it met *C*. Both *A* and *C* were unacquainted opponents but familiar with the central cage. During that time, hen *B* observed the encounter between *A* and *C* from its satellite cage through the mesh door where it saw *C* dominating *A* (condition **E**) or *A* dominating *C* (condition **C1**). Under control condition **C2**, *B* hens observed 2 unfamiliar hens, *A* and *C* resolve conflict on the upper level of the setup, and *B* watched *A* and *C* hens on the lower level. After 90 min, *B* and *B* hens of condition **C2** were transferred back to the

satellite cage of their respective original levels where they spent 15 min in isolation.

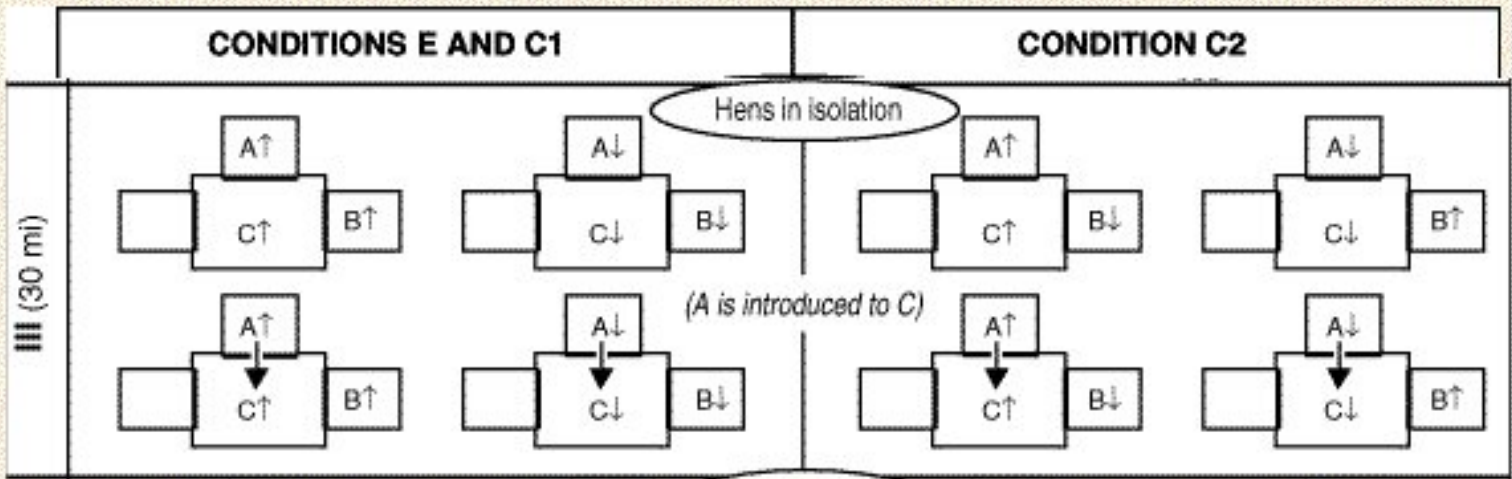
At step V, under all conditions the door between the satellite cage where *B* hens waited was opened and *B* hens were incited to move into the central unit to meet *A* and *C*.



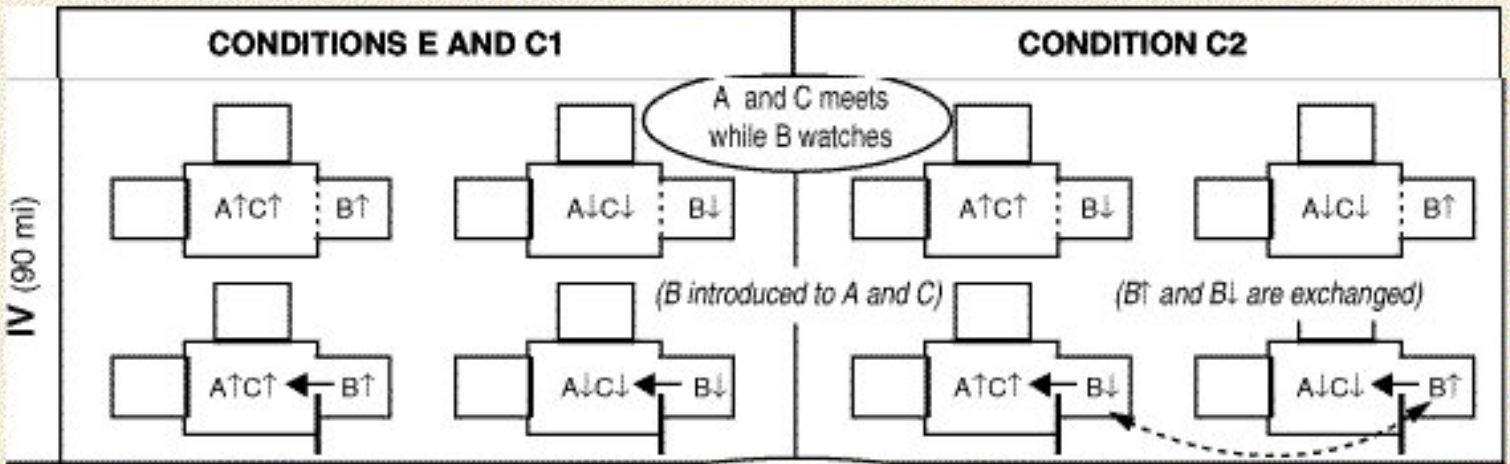
Step I: Four hens are matched for weight, comb surface and colour and put in isolation for 120 minutes in the 4 cages of each setup level.



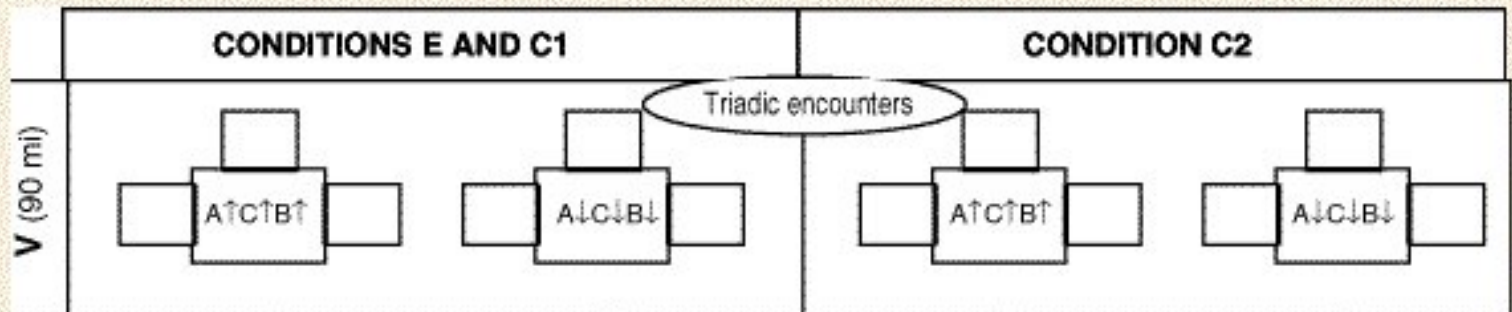
Step II: Dyadic encounters between *A* and *B*, and *C* and *D*. Hen *D* is not used further. Under condition *C2*, hens *B* from the top level of the setup are interchanged with that of the bottom level.



- **Step III:** Hens remain in isolation for 30 min.



Step IV: A and C meet while B watches from its satellite cage. Under condition C2, B watches two strangers meeting. B hens are again interchanged.



- **Step V:** B joins A and C and their behaviour is videotaped.

Fig. 2. The 5 successive steps followed by the present research to assemble the triads.

Dominance criterion. For all dyads and triads, a hen was considered dominant over another one when it delivered 3 consecutive attacks: peck, jump on, or claw (Kruijt, 1964; McBride et al., 1969), each followed by signs of submission by the opponent (flight, avoiding or crouching), and by a 30-min period during which the presumed subordinate hen did not counter attack the initiator. If after 90 min of monitoring the relationship between any 2 hens remained unresolved, they were separated and returned to their respective pens. All dyadic and triadic encounters were recorded on videotape to be analysed in

detail.

Results

Our main hypothesis was that the bystander hen *B* would use differently the information gained on seeing its prior dominant defeating *C* in condition **C1**, or being defeated by *C* in condition **E**.

TABLE 1

Dominance outcomes between the bystander *B* and *C* hen under the 3 conditions of information

CONDITIONS	<i>B</i> had seen	<i>B</i> > <i>C</i>	<i>C</i> > <i>B</i>	<i>B</i> ? <i>C</i>
E <i>N</i> =15 triads	<i>C</i> > <i>A</i>	0	15	0
C1 <i>N</i> =16 triads	<i>A</i> > <i>C</i>	8	8	0
C2 <i>N</i> =15 triads		4	6	5

C>*A* : *C* dominates *A*

B?*C* : unresolved

As can be seen from Table 1, when *B* hens saw their prior dominants *A* defeated by *C* (condition **E**) they in turn always submitted to *C*. By contrast, when *B* hens saw their prior dominants being victorious over *C* hens they defeated *C* hens in 50% of cases. This repartition 100%:0%, 50%:50% depending on what *B* hens had observed is highly significant to a Fisher test ($P < 0.001$, one-tail).

TABLE 2

First to attack once *B* had joined the prior dominant *A* and stranger *C* and mean attack frequency.

CONDITIONS	<i>B</i> had seen	First to attack		Mean attack frequency	
		<i>B</i>	<i>C</i>	<i>B</i>	<i>C</i>
E	<i>C</i> > <i>A</i>	0	15	0.	23.53
C1	<i>A</i> > <i>C</i>	8	8	7.	5.18
C2!		4	6	1.33	6.87

! Only *N*=10 complete triads considered; other 5 never settled

Table 2 indicates that under condition **E** *B* hens never initiated attack against *C* hens (0:15, one-tail binomial test, $P < 0.001$). In condition **C1**, where *B* hens had 50% odds by chance alone of defeating *C* rivals, they first attacked *C* in 50% of cases (8/16). *B* hens were also more aggressive toward *C* when they

had seen *A* obtaining victory over *C* hens ($Z=2.39$, $P<.02$, Mann-Whitney U test). In condition **C2**, *B* hens watched 2 strangers settling dominance and thus had no information on the actual relationship between *A* and *C* hens they were to meet at step *V*. *B* hens first initiated contact in only 27% of cases (4/15), which approximates the overall chances of defeating *C*, since they had no chance if $C>A$ and 50% chance if $A>C$, *i.e.* $(0+50\%)/2$. When *B* hens had seen *A* and *C* resolve conflict (conditions **C1** and **E**), they in turn always resolved conflict with *C* whatever the direction of the issue between *A* and *C* at step *IV*. Under condition **C2**, *B* hens had no indication of the respective status of *A* and *C* towards each other; this ignorance could explain why more relationships between *B* and *C* hens remained unresolved (5/15). The repartition of outcome frequencies had a strong trend of being different when sample was compared to **C1** using a log-likelihood ratio test or G-Test (Sokal and Rohlf, 1995) ($G=5.017$, $df=2$, $P<0.0814$) and were definitively different when compared to the **E** condition ($G=9.282$, $df=2$, $P<0.0096$).

TABLE 3

First behaviour initiated by bystander *B* once it had joined the prior dominant *A* and stranger *C*

CONDITIONS	<i>B</i> had	<i>B</i> avoids	<i>B</i> approaches or	<i>B</i>
	seen	<i>C</i>	attacks	approaches
			<i>C</i>	<i>A</i>
E	$C > A$	15	0	0
C1	$A > C$	7	9	0
C2		10	3	1

Table 3 presents the first behaviour initiated by *B* hens after they stepped into the central cage. Bystanders behaved differently toward the stranger *C* depending on what they had just witnessed. All bystanders that had witnessed the defeat of their prior dominant (condition **E**) avoided the stranger directly, and none of them attacked or approached the stranger. Under condition **C1** where the bystander had seen the stranger being defeated by the prior dominant, they equally approached or avoided the stranger ($G=0.012$, $df=2$, $P=0.72$). In that respect the difference between conditions **E** and **C1** reaches statistical significance ($G=10.94$, $df=2$, $P<0.001$). As for *B* hens of condition **C2**, their behaviour resembled that of bystanders of the **E** condition ($G=1.942$, $df=2$, NS) and a majority of them avoided the stranger ($G=12.64$, $df=2$, $P<0.002$), more often than in condition **C1** ($G=11.23$, $df=2$, $P<0.004$).

Discussion

The present results support the hypothesis that during hierarchy formation a hen observing agonistic interactions and conflict settlement between its former dominant and a stranger can use this information against the latter when in turn confronted by it. Its future behaviour may depend on the issue of the conflict it was in a position to observe. When the bystander had witnessed the domination of its prior despot by the stranger, the bystander behaved as if it estimated itself as having no chance of defeating in

turn the new despot: it never initiated attack against the stranger, and upon being attacked, readily submitted to it. On the contrary, when the bystander had seen its prior despot *A* defeating the stranger *C*, it behaved as if it estimated itself as having some chances against the stranger: it initiated attack against the stranger in 50% of cases and was successful in dominating it in the same proportion.

Globally taken these results suggest that a hen on standby can gain some information on seeing its prior dominant settling conflict against a stranger. If this is the case, the nature of the information gained remains to be identified. There are several possibilities, one of which is the information bearing on the *relationship* between *A* and *C*; that is hen *B* knows when it joins *A* and *C* that *A* dominates *C*, or the reverse, that *C* dominates *A*. The fact that *B* readily attacked *C* when it had seen *A* dominating *C*, but did not attack when it had seen the reverse, supports the interpretation that it is the relationship that was identified by the bystander. But there are alternate explanations as well.

The information obtained by the observing hen could more simply concern *C*'s resource holding potential (*RHP*) as compared to its own. Observation could allow the hen on standby to assess from a distance the agonistic potential of the stranger, especially when the latter compared itself to the prior despot as a gauged point of reference. Information thus gained could have been that *C*'s *RHP* was larger/smaller than that of *B*. From this simple information, *B* could decide to attack *C* or to refrain from doing so; transitivity would be favoured in the condition that in the hen there is some causal link between initiating attack and obtaining victory over the opponent as suggested by Chase (1982). Ligon (1990) reported a significant relationship between initiating an attack and winning the fight in the hen, observation that is amply confirmed by this research.

Instead of bearing on the stranger's *RHP* the information obtained by *B* could concern the «status» of the opponent. «Status» is here taken in the very broad sense of «class», that is high or low in a dominance structure, and not as characterizing the nature and direction of the relationship existing between two individuals. Zayan (1987) proposed that the identification of «status» could be based on a perceptive process where the animal interprets morphological and behavioural cues as those of a potential dominant and not as a former dominant. According to Zayan, animals have been shaped to respond in a specific way to agonistic displays. Therefore, a hen will produce the most appropriate response in response to an agonistic behaviour. Zayan (1992) suggests that the previous status and current agonistic state would be assessed from a set of observable cues or biophysical indicators provided by the individuals' morphological and motor patterns, visually discriminated, and interpreted using past associations with similar *classes* of conspecifics. Graves et al. (1985) found that *Gallus* females in mixed-sex flocks that did not have information about male dominance status, oriented towards and stayed near high ranking males. This suggests that they could detect the quality of males from their physical characteristics and, if available, the information concerning male-male interactions. It is thus plausible that *Gallus* females gauge the quality of other females using similar cues.

Simple familiarity of *B* with *C* can also be ruled out to account for the use of different strategies by *B* against *C* under conditions **E** and **C1**. In effect, under both conditions, *B* hens had the occasion to watch *C* meeting *A* at step IV. Moreover, our observations indicate that the observer was fully aware of the presence of other hens in the adjacent cage. In fact, the bystanders spent most of the time near the sliding door during the confrontation of hen *A* and *C*, and as soon as that door was open, most *B* hens quickly stepped into the central unit to join the other two. The fact that under condition **C2** more relationships between the bystander and *C* remained unsettled after 30 min can be attributed to unfamiliarity of *B* with *C*. In condition **C2**, *B* was also less familiar with *A* since the former could not witness the encounter of its

prior dominant with *C*. Thus, since bystanders of condition **C2** were less familiar with *A* and *C* than they were in other conditions, more time was required to get familiar. This could explain why more encounters between *B* and *C* did not resolve within the allotted 90-min periods.

A word of caution is in order about a methodological limit in the present research that may preclude drawing straightforward inference about differences between conditions **C2**, **E**, and **C1**, and especially concerning the higher number of triads that did not reach completion under condition **C2**. Strictly speaking, condition **C2** was not a perfect control for **E** and **C1** conditions because *B* hens were more frequently handled under condition **C2** than they were under **E** and **C1**. More handling was required to have *B* hens watch strangers. Thus they were handled twice, once from the central unit to the satellite cage of the other level, and once from the satellite cage of a given level to the satellite cage of the other level. Hens were very tame and accustomed to be handled. Moreover, we waited 15 min after the handling to have them recuperate. Nonetheless, this could account for the fact that more relationships remained unsettled between *B* and *C* hens. Future research should take care to equalize handling across *B* hens in all conditions as well as the handling of *A* and *C* hens in all conditions rather than *B* hens of condition **C2** only. However, such a methodological restriction does not apply to conditions **E** and **C** in which *B* hens were not handled.

There is still a rival explanation for the difference in strategies used by *B* hens of conditions **E** and **C1**. The explanation simply focuses on the respective prior experiences of bystanders and strangers, rather than on the information that bystanders gained on the relationship between their prior despot and the stranger. Under condition **C1**, *C* and *B* hens had both experienced recent defeat against *A*. Under condition **E**, *C* had experienced victory against *A* while *B* had experienced defeat. It has been shown in *Xiphophorus* fish that victory was equiprobable when other asymmetries were neutralized and when both opponents had received prior defeat experiences (Beaugrand and Zayan, 1985). It is also well established in fish and hens that in encounters between prior winners and prior losers, prior winners systematically defeat prior losers (Beaugrand and Zayan, 1985; Cloutier et al., 1996). Under condition **C2**, *C* hens had in reality always been defeated by *A*. Thus, that the bystanders defeated strangers in 40% of cases more or less corresponds to the objective chance of a prior loser defeating another prior loser, that is 50%. In *Xiphophorus*, encounters between 2 prior losers also have about the same duration as that between a prior winner and a prior loser (Beaugrand, unpublished data). This result is confirmed by the present research when conditions **E** and **C1** are compared on that aspect. In both conditions, the duration of conflict depends on decisions taken by prior losers to cede to the prior winner or to the prior loser which they confronted. Since prior losers in both conditions were probably willing to continue fighting for durations that were taken from a common distribution, on the average, durations of conflicts did not significantly differ from one condition to the other. Along the same lines, under condition **E**, the fact that *C* hens, which had defeated *A* hens, were always the first to attack the bystanders can be accounted for by the respective divergent prior experiences of *B* and *C* hens rather than by the information gained by *B*. After all, *C* hens had won over *A* hens and were more «confident» than *B* hens, which had been defeated by *A*. Thus, it was to be expected that the more «confident» hen would attack first and would win. Moreover, under condition **E**, *C* hens had experienced victory in the central unit whilst *B* hens had experienced defeat in the same place. Cloutier et al. (1995) have shown that hens, which had previously lost, were disadvantaged when the encounter occurred in the same site as that of their prior defeat. They did not find a converse locus-dependent advantage for prior winners. The difference in outcome and behaviour between conditions **E** and **C1** concerning *B* and *C* hens could well be accounted for by locus dependent defeat as well as by asymmetry in prior dominance experience or by both effects combined, rather than by genuine information gained by bystanders watching their prior despot and a stranger settling conflict.

Nonetheless, examination of what the bystander and stranger did first when the bystander moved into the central cage to meet *A* and *C* hens strongly supports the explanation that is based on information gained by the bystander *B* rather than on the respective experiences of *B* and *C*. Under conditions **E** and **C1**, the observer had (potentially) gained different information on the relationship between *A* and *C*, or only on *C*. However, the experience of *B* was kept constant, that is under both conditions *B* had experienced defeat to *A*. In contrast, *C* had received divergent experiences: victory under the **E** condition but defeat under **C1**. On the one hand, assuming that experience just received determines what *B* and *C* hens will do first upon meeting, one can expect that *B* hens having received the same experience under both conditions will behave identically. On the other hand, *C* hens having received contrary experiences should behave differently. For instance, under condition **E**, *C* hens, which had just experienced victory over *A*, could be expected to attack *B* as soon as it enters to satisfy double attacks that favour double dominance of *C* (Chase, 1982). As shown in Table 3, it was not the case; *C* did not approach or attack *B* more often when it had just defeated *A*. In fact, under both conditions, most behaviours were initiated by *B*. However, comparing conditions, the behaviour of the newcomer had different functions that were highly coherent with what it had witnessed, that is to avoid the stranger that had won (condition **E**), or to confront it when it had lost, and when there was a possibility for the bystander to defeat it in turn (condition **C1**).

Whatever the nature of the information used, it remains ambiguous in the present research whether *B* hens applied this information through *transitive inference*, which would determine the kind of behavioural interaction they will engage in. The present research was not adequately designed to test for the capacity of transitive inference in hens. Whilst our results can possibly serve as evidence for the capacity of transitive inference in the hen, some unspecified process, perhaps of a simpler nature, might also be accountable. However, if dominance hierarchies have predisposed social animals to develop sensitivity to transitive relations (Gillan, 1982; Harcourt, 1988; Davis, 1990a), they might also be the only adequate context in which competent evidence can be obtainable. As suggested by Zayan (1994), perhaps do we have here a case of mental representation where a hen preserves not only the identity of two other hens but also two dominance-subordination relationships, and from these infers the transitive property of this order relation.

The capacity in the hen to infer transitivity would have profound implications during peck-order formations in hens. Cloutier et al. (1996) found that when three hens were simultaneously introduced to each other, hens selected each other to form pairs. The two hens predicted from individual differences to occupy the highest rank, first settled dominance, followed by settlement between the winner of the previous encounter and the bystander. In addition, experimentally introduced individual differences were found to account for hierarchical position in these triads (Cloutier et al., 1996). The present data complete this picture by a cognitive selection mechanism in which, as correctly foreseen by Slater (1986) and Zayan (1987), the bystander is observing the encounter, and will later retreat from the winner or attack the loser on the basis of the experience. These results move us beyond Chase's (1982) sequential model of hierarchy formation, which essentially focused on double victories and defeats to account for transitivity. Chase's (1982) model was elaborated from cases in which individual differences were neutralized. In such controlled conditions, resolution sequences of the double dominance and double subordination types appeared as the only salient factor that could explain transitivity. However, as suggested by the present results, these resolution sequences could well be accounted in turn by the cognitive capacity of bystanders to use ulteriorly and coherently information gained by seeing their prior dominants/subordinates dominating or being dominated in turn by strangers.

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Résumé

La présente recherche examine le rôle de l'observation au cours de la formation de triades hiérarchiques chez la poule domestique. Les résultats suggèrent qu'une poule assistant à la rencontre agonistique et à l'établissement d'une relation de dominance entre son ancienne dominante et une poule étrangère, utilisera cette information quand elle sera à son tour confrontée à l'étrangère. Dans une première condition (**E**, $N=15$ triades), une poule observatrice assistait à la défaite de son ancienne dominante par une étrangère avant de rencontrer elle-même cette dernière. Dans une seconde condition (**C1**, $N=16$ triades), l'observatrice assistait à la victoire de son ancienne dominante sur l'étrangère. Dans une troisième condition (**C2**, $N=15$ triades), l'observatrice assistait à la rencontre de deux poules étrangères; puis, elle rencontrait son ancienne dominante et une étrangère que la dominante venait de défaire sans que l'observatrice en soit informée. Les stratégies comportementales utilisées par l'observatrice dépendaient de ce qu'elle avait observé. Lorsqu'elle avait assisté à la défaite de son ancienne dominante (condition **E**), elle se comportait comme si elle n'avait aucune chance de défaire l'étrangère. La poule observatrice n'était jamais la première à menacer ou à attaquer; lorsqu'elle était attaquée par l'étrangère, elle se soumettait immédiatement. Lorsque l'observatrice avait au contraire assisté à la défaite de l'étrangère par sa dominante (condition **C1**), elle se comportait comme si elle avait des chances de défaire l'étrangère. Elle initia 50% des attaques et domina l'étrangère dans 50% des cas. Sous la condition **C2**, l'observatrice n'avait aucune information sur la relation qui existait effectivement entre son ancienne dominante et l'étrangère. Ses chances de défaire l'étrangère étaient de 25%. Celle-ci fut la première à initier un contact avec l'étrangère dans 27% des cas. Par contre, les observatrices dominèrent les étrangères dans 40% des cas. Ces résultats suggèrent que les observatrices des conditions **E** et **C1** possédaient de l'information sur la relation (dominance-soumission) qui s'était établie entre leur ancienne dominante et l'étrangère et qu'elles l'utilisaient par la suite de façon cohérente, peut-être par inférence transitive, contribuant ainsi à rendre transitives les relations de dominance dans la triade. Des explications rivales sont aussi examinées.