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Use of kind information for object individuation in young domestic chicks

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Abstract In this paper, we studied the ability of newborn chicks to use kind information (sortal objects) provided by social and food attractors to determine the number of distinct objects present in an event (object individuation). Newly hatched chicks were reared with five imprinting objects and were fed mealworms. Chicks' spontaneous tendency to approach the larger group of items was exploited. At test, on day 2 post-hatching, chicks observed two events in which objects, differing in kind, were each hidden behind one of two identical screens. Approaching either screen was considered a preferential choice. In Experiment 1, chicks presented with two social versus two food attractors did not exhibit any preference. In contrast, in Experiment 2, when chicks saw two different attractors (one social and one food) hidden behind a screen and one attractor hidden twice (i.e. moved back and forth two times) behind the other screen, they spontaneously approached the two different attractors rather than the single one seen twice. An explanation based on the preference for the more varied set was ruled out in Experiment 3: chicks did not preferentially choose between two different versus two identical objects when both groups were simultaneously presented. Results suggest for the first time that a non-human species uses kind information for individuating objects in a cross-basic-level contrast (i.e. food and social items) with minimal experience. As social and food stimuli differ in property as well as in kind information, the alternative explanation accounting for use of property information alone is also discussed.

Keywords Object individuation · Sortal concepts · Domestic chicks · Kind/sortal information

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Introduction

Object individuation is the process that allows one to determine the number of objects in an event or a scene. To establish the numerical identity of a set, it is necessary to comprehend that different objects have distinct identities such that each of them can be considered as a different unit. Adult humans individuate different objects on the basis of three sources of information (Spelke 1990; Xu 2007). *Spatiotemporal information* includes the generalisation that objects typically travel on spatiotemporally continuous paths, implying that the same object cannot occupy two places at the same time and that two objects cannot be in the same place at the same time. *Property information* includes the generalisation that objects do not usually transform their features, such as colour, size, shape or pattern. *Kind/sortal information* includes the generalisation that objects do not usually change kind membership: the same object, seen in two instances, must fall under the same sortal concept (a cup remains a cup and a pencil remains a pencil over time). A sortal concept is therefore a concept providing principles of identity and principles of individuation (Hirsch 1982; Wiggings 1980).

Since the seminal paper of Xu and Carey (1996), it has been argued that infants increasingly differentiate kind concepts in acquisition. Several studies, using preferential looking (Spelke 1990; Xu and Carey 1996) or manual reaching (Xu et al. 1999; Van de Walle et al. 2000; Xu and Baker 2005)

methods, demonstrated that the critical age at which infants fully master the ability to use kind information is 12 months. Such a capability matures from a concept of objects that is at first undifferentiated and that, over the course of the first year, becomes differentiated into various kinds of categories (i.e. sortal concepts). Starting from 4 months after birth, infants represent objects as entities which travel on spatiotemporally continuous paths (Spelke et al. 1995; Xu and Carey 1996; Aguiar and Baillargeon 1999). At around 10 months, infants are able to use kind information for establishing object numeracy, but only when presented with a contrast across basic levels, such as animate (i.e. humanlike) versus inanimate objects (Bonatti et al. 2002). When a non-animate toy (i.e. a car) emerged from behind a screen and then returned behind it, then a human-like toy (a doll) emerged and subsequently returned behind the same screen, and then the screen was lowered, infants looked longer at the outcome of one object than of two objects. In contrast, infants did not look longer when a male and a female doll were used (within-basic-level-kind contrast), showing that they did not possess property distinction between two persons (Bonatti et al. 2002). Finally, 12-month-old infants are able to use kind information before using property alone: they succeeded in the "is-it-one-or-two" task when presented with bottles and cups earlier than when they succeeded with blue cups and red cups (Leslie et al. 1998; Xu et al. 2004). Thus, authors suggested that kind distinctions are inductively deeper than property distinctions.

The developmental change in the ability to use property/kind information has been suggested to be linked with the acquisition of language, in particular with noun understanding (Xu 1999, 2002; Rivera and Zawaydeh 2006). At 9 months, infants succeed in the "is-it-one-or-two" task, when the presentation of the objects is verbally associated with familiar or unfamiliar sortal labels, such as "cup" and "ball" or "fep" and "zav". On the contrary, they fail when the objects are labelled with emotional vocalisations, beeps or other non-linguistic sounds (Xu 2002). Converging evidence was also found in a variant of the manual search paradigm, in which 12-month-old infants heard the experimenter labelling the hidden contents of the box with two different words (i.e. "a car" and "a dog") or with a same word repeated twice (e.g. "a car" and "a car"). Infants searched more persistently in the box only when they have previously heard two different words: this behaviour indicates that they expected to find two objects (Xu et al. 2005).

Taken together, this evidence supports the hypothesis that object individuation according to kind information is uniquely human, because it is linguistically mediated (Xu 2002), with language playing a privileged role in helping infants to develop representations of object kinds (Xu 2010). Nonetheless, evidence from younger infants supports the independence of object individuation ability from language. Under certain conditions, if the cognitive demand is reduced or the event simplified, even younger infants do use featural/property information for object individuation (Wilcox and Baillargeon 1998a, b; Wilcox and Chapa 2002; Wilcox and Schweinle 2002; McCurry et al. 2009).

Comparative research has shown that some non-human species also use some of the above described types of information for object individuation. Munakata et al. (2001) demonstrated that rhesus monkeys (*Macaca mulatta*) use featural information to parse an array of adjacent food items into distinct objects, and adult monkeys represent those objects as separately movable, an ability available to human infants only at around 12 months of age.

Adult non-human primates seem to be able to use spatiotemporal as well as property/kind information for individuating objects (Uller et al. 1997; Santos et al. 2001; Phillips and Santos 2007; Mendes et al. 2008, 2011). In particular, using a modified version of the habituation methodology employed by Xu and Carey (1996), Uller et al. (1997) demonstrated that rhesus monkeys succeeded in individuating objects using both spatiotemporal and property/kind information. Subjects were presented with an event in which a carrot was removed from, and then replaced behind, a screen, followed by a piece of squash being removed from and replaced behind the same screen. Once the screen was lifted, either the expected (a carrot and a squash) or an unexpected event (only one of these objects, either the carrot or the squash) was presented, in separate trials. Monkeys looked longer at the latter event, demonstrating that they expected two objects. A possible criticism of this study is that monkeys could have solved the problem without using kind representation but relying instead on property information alone (Xu 2002): the objects used as stimuli were different in kind but also in property, such that they looked perceptually different. However, in subsequent research, Phillips and Santos (2007) provided evidence that rhesus monkeys successfully individuated different kinds of objects even when their perceptual information was held constant. Stimuli employed were identical pieces of different kinds of fruit, coconuts and apples, which can be considered a within-basic-level-kind contrast. Again, monkeys' performance could have been based on associative learning. Monkeys could have learned, through experience with coconuts and apples, not kind representations for those fruits, but instead clusters of properties that became associated through experience (Phillips and Santos 2007).

Recently, object individuation has been shown also in another mammalian species, the domestic dog (*Canis familiaris*, Bräuer and Call 2011), comparing the performance of dogs and great apes using the violation of expectation paradigm. The animals were shown either good or bad food items placed inside a cup. At test, they could explore the content of the cup and find either the same food as earlier presented or a different kind of food. The number

of trials in which great apes looked inside the box and dogs smelled the cup (within 10 s of recording) was scored. Results demonstrated that they reacted with surprise both to negative (i.e. good food being substituted with bad food) and positive (i.e. bad food being substituted with good food) replacements. Thus, it seems that dogs and great apes show similar behavioural patterns suggesting that they are capable of individuating objects according to their property/kind information.

Evidence from animal models, therefore, supports the idea that object representation according to property/kind is independent from language. It remains to be understood how early animals develop this knowledge and how similar are the mechanisms at the basis of these abilities in the different species.

Only one study thus far has investigated object individuation in very young animals (Fontanari et al. 2011), establishing that this ability can be available early in development and independent from experience or linguistic capacity. Three-day-old domestic chicks (*Gallus gallus*) were tested using an experimental design inspired by the event-mapping task of Xu and Carey (1996). Chicks' spontaneous tendency to approach the larger group of social imprinting or food objects (Rugani et al. 2009, 2010, 2011, 2013; Regolin et al. 2010) was exploited as behavioural tool. Through filial imprinting, chicks develop a strong attachment towards objects they are exposed to soon after hatching. Usually, the natural imprinting stimulus is the mother hen, but artificial objects prove to be equally successful in triggering social attachment and social bonding in young chicks, with moving stimuli preferred over stationary ones (see Mascalzoni et al. 2010 and for a general review Bolhuis and Honey 1998). In the study by Fontanari et al. (2011), newborn chicks were reared with objects differing in colour, shape or size. At test, each chick was presented with two groups of events (each ending behind either of two identical screens): two objects differing along one property dimension consecutively presented versus the same object presented twice. Chicks spontaneously approached the screen hiding two different objects rather than the one hiding the single object, demonstrating they use property information (colour, size or shape) for object individuation (Fontanari et al. 2011).

The present study represents a first attempt at studying the ability to use kind information for object individuation in a bird species, as well as in a very young animal.

Experiment 1

Domestic chicks are precocial birds, able to follow the mother hen and the siblings and to feed independently soon after birth. For this reason, it looks plausible that they precociously exhibit some competences for the categories of objects most crucial to their survival. Rudimentary representations of object categories may in fact prove useful for an animal dealing with its own environment and may therefore result in an ecological advantage. Feeding and social behaviour (along with predator avoidance) constitute two main domains in chicks' early life. Thus, food and social stimuli were used in a paradigm analogous to that previously used for the investigation of property information in this same species (Fontanari et al. 2011). Both categories are crucial to the survival of the newborn chicks, though they imply very different behavioural responses, and plausibly, different levels of motivation are associated with either domain under different environmental conditions. The first experiment investigated under which conditions chicks would be equally motivated to respond to food or to social stimuli. As previous studies demonstrated that chicks tend to approach the larger group of objects (Rugani et al. 2009, 2010, 2011, 2013), chicks were tested with two sets of identical size. Chicks were presented with a 2 versus 2 stimuli comparison (two social stimuli vs. two food stimuli, both elements in a set being simultaneously presented). Should chicks choose any of the two groups of stimuli, its choice would likely indicate a preference for that category of objects. No preference would be displayed under conditions in which no bias is present towards one category.

A lack of interest for the two attractors could also explain lack of preferential choice and therefore should be ruled out beforehand. For this purpose, prior to the actual test, subjects underwent two tests designed to probe motivation to approach, respectively, social stimuli (imprinting motivational estimation) and food stimuli (food motivational estimation). Only those chicks that promptly responded to both stimuli's categories moved on to the actual test.

Materials and methods

Subjects stimuli and rearing conditions

Subjects were 12 female "Hybro" (a local variety derived from the White Leghorn breed) domestic chicks (*G. gallus*) obtained weekly from a local commercial hatchery (Agricola Berica, Montegalda, Vicenza, Italy) when they were only a few hours old. On their arrival at the laboratory, chicks were immediately housed in standard metal home cages (28 cm wide × 32 cm long × 40 cm high) at controlled temperature (28–31 °C) and humidity (68 %), with food and water available ad libitum in transparent glass jars (5 cm in diameter, 5 cm high) in each corner of the home cage. The cages were constantly (24 h/day) lit by fluorescent lamps (36 W), located 45 cm above the floor of the

cages. Each chick was placed singly in one cage, together with five identical rounded objects made of red plastic, which constituted its imprinting stimuli. Each object was a "Kinder surprise" capsule (Ferrero S.P.A. Alba, Cuneo, Italy) measuring $4 \times 3 \times 3$ cm (which we will hereafter refer to as a "ball") and was suspended in the centre of the cage by a fine thread at approximately 4–5 cm from the floor, so as to be located at about eye level for the chicks.

Chicks were fed with mealworms (*Tenebrio molitor* larvae) which later served as the food stimuli at test. In the morning of day 1 (once housed in the home cage), one mealworm was gently offered to the bird (by picking it up with tweezers and keeping it in front of the chick's beak to prompt pecking). Three hours later, a second mealworm was placed on the floor of the home cage, in order to let chicks catch and eat it. Only chicks that ate both mealworms entered the training phase (i.e. 90 % of the subjects).

Chicks were kept in the standard rearing conditions described above for 2 days: from the morning (11.00) of the first day (i.e. Monday, the day of their arrival, which was considered as day 1) to the day after (Tuesday, day 2). In the afternoon (14.00) of day 2, they underwent training. Approximately 1 h later, they took part in the motivational estimations and approximately 1 h after the motivational estimations they underwent the proper testing session.

Apparatus

Training and testing took place in an experimental room, located near the rearing room, in which temperature and humidity were maintained at 25 and 70 %, respectively. The room was kept dark, except for the light coming from a 40 W lamp placed approximately 80 cm above the centre of the apparatus. The testing apparatus (Fig. 1) consisted of a circular arena (95 cm in diameter and 30 cm outer wall height) with the floor uniformly covered with a white plastic sheet. Within the arena, adjacent to the outer wall, there was a holding box ($10 \times 20 \times 20$ cm), where the chick was briefly confined before the beginning of each trial. The box was made of opaque plastic sheets, with an open top allowing the insertion of the chick before each trial. The side of the holding box facing the centre of the arena consisted of a removable clear glass partition (20×10 cm), in such a way that the subjects, while confined, could see the centre of the arena. During the training phase, one single cardboard screen (16×8 cm) was used, positioned in the centre of the arena, in front of and 35 cm away from the holding box. During testing, two opaque cardboard screens, identical to the one used during training (i.e. blue coloured with a yellow "X" printed on them), were positioned in the centre of the arena (see Fig. 1), symmetrically with respect to the front of the

holding box (i.e. 35 cm away from it and 20 cm apart from one another).

Procedure

Training In the afternoon of day 2, chicks underwent a preliminary training session. Each chick was placed within the testing arena (not confined in the holding box), in front of one screen, together with a single visible imprinting stimulus (identical to one of the five stimuli used during rearing). The stimulus was held from above by the experimenter (not visible to the chick), via a fine thread, and initially kept suspended between the holding box and the screen. The chick was left free to move around and get acquainted with the environment for approximately 5 min. Thereafter, the experimenter slowly moved the ball towards the screen and then behind it, until it disappeared completely from the chick's sight. This procedure was repeated a few times, until the chick responded by promptly following the ball behind the screen. Thereafter, the chick was confined to the holding box, behind a transparent frontal partition through which it could see the ball being moved and hidden behind the screen. As soon as the ball had completely disappeared from sight, the chick was released into the arena by lifting the transparent partition. Every time the chick followed the imprinting stimulus behind the screen, it was allowed to spend a few seconds close to it, as a reward. The whole procedure was repeated until the chick had rejoined the imprinting stimulus two consecutive times.

Then, the food stimulus (one mealworm, suspended with a fine thread) was employed using the same procedure. The training ended when the chick had following the food stimulus behind the occluder two consecutive times. On
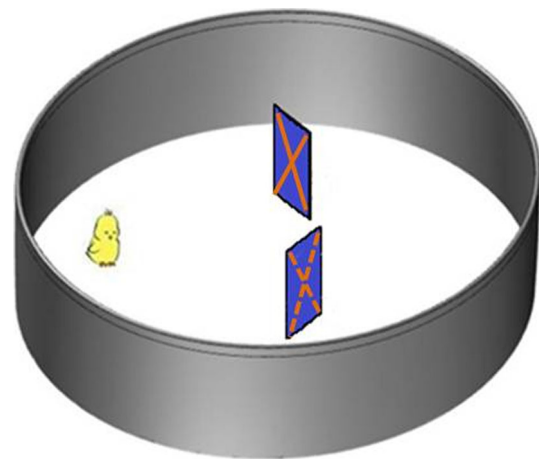

Fig. 1 Representation of the apparatus employed in the experiments (only one of the two screens was present in centre of the arena in the training phase)

average, to complete the training, a chick required between 15 and 20 min.

Motivational estimations Before the test and about 1 h after the training, each chick (once having successfully completed the training phase) underwent two motivational estimations (i.e. imprinting and food motivational estimation). The aim of such estimations was to ensure that chicks would adequately respond to both attractors in a situation similar to that later faced at test.

Imprinting motivational estimation: the chick was required to rejoin its imprinting stimulus once it had disappeared behind the screen in ten consecutive trials, and the response time (seconds) was measured. If during one trial a chick did not approach the screen within 3 min, the trial was considered aborted and repeated immediately afterwards. After three consecutive null trials, the chick was discarded from the experiment (this occurred for about 5 % of chicks, not included in the final sample).

Food motivational estimation: eight pieces of mealworm were placed on a white cardboard (18 × 30 cm) spaced out about 4 cm from one another. The cardboard was placed in the middle of the experimental arena, and the time (seconds) taken by the chick to eat all of the mealworms was scored. If the chick did not eat all eight pieces within 5 min, it was discarded from the experiment (this occurred in about 20 % of chicks, not included in the final sample).

The order of presentation of the motivational estimations was randomised across subjects.

All subjects that passed the training and that responded on each of the motivational trials were admitted at the testing phase. Only about 50 % of the initial sample of birds completed the training phase (loss of about 25 % of subjects, not included in the final sample) and both motivational estimations (loss of about 25 % of subjects, not included in the final sample).

Testing The testing phase took place 1 h after the end of the motivational estimations. At the beginning of each testing trial, the chick was confined within the holding box, behind the transparent partition, from where it could see two identical screens in the centre of the arena.

The chick was shown two events overall, each of them taking place by a different screen. Each event consisted of the simultaneous presentation of two attractors (two imprinting or two food stimuli). The two events were shown separately, and consecutively, i.e. the second event took place just after the end of the first one, the order of presentation being randomised.

Before the beginning of each trial, all stimuli were positioned behind the screens. Two extra pieces of mealworms (which would constitute the reward) were also placed behind the screen hiding the food stimuli. During these manipulations, an opaque partition (made of a white paper sheet) was temporarily placed in front of the holding box in order to prevent the chick's sight. The opaque partition was removed at the start of each trial. Two identical stimuli (either social or food) simultaneously appeared from behind one screen and slowly moved towards the confined chick, they remained in front of the chick (beyond the clear partition) for a few seconds, and then moved behind the same screen from which it originated, out of view from the chick. Subsequently, the same procedure was carried out for the other kind of stimuli, from the other screen. In this way, an equal number of events, involving an equal number of stimuli (i.e. two), took place at each screen, differing in the kind of attractor stimuli involved (either social or food).

The whole procedure lasted between 20 and 25 s. Each group of stimuli took 3 s to be moved from behind the screen to the front of the holding box, where it was kept for another 3 s, and then it took 3 s to be moved back behind the screen (9 s overall). About 2 s elapsed from the disappearance of one group of stimuli and the appearance of the next one. Immediately after the disappearance of both sets (with a delay of 5 s), the transparent partition was removed to allow the chick to move around and search for its preferred stimuli within the arena. To prevent the chicks from spotting the hidden stimuli before having circled almost completely around of the screen, screens were provided with 3 cm bent back edges on the two vertical sides. A choice for one screen was scored when the chick's head had entered the area behind that screen (beyond the side edges). Only the choice for the first screen visited was scored, and thereafter, the trial was considered over. The response time was also scored, i.e. time (seconds) taken by the chick to detour the chosen screen. At the end of each trial, the chick was allowed to spend a few seconds together with its "social companions" or to eat the pieces of mealworms presented behind the chosen screen. If a chick did not approach either screen within 3 min, the trial was considered null and void and it was repeated immediately afterwards. After three consecutive null trials, the chick was placed back within its own rearing cage (in the presence of the imprinting stimuli) for approximately 1 h before being resubmitted to further trials. If a chick failed to respond (three consecutive null trials) across three attempts at testing, it was discarded from the experiment (this occurred for about 5 % of chicks, not included in the final sample).

Each chick underwent one complete testing session of ten valid trials. The order of presentation (which event was first and which second) of the two groups of stimuli as well as the position (left–right screen) of appearance and disappearance of either set was counterbalanced as much as possible within each chick's ten testing trials.

The number of trials in which each chick chose the screen hiding food stimuli (which was arbitrarily regarded

as the correct choice) was considered, and percentage was computed as: (number of correct choices/10) × 100. A one-sample two-tailed *t* test was performed for assessing significant departures from chance level, i.e. 50 %. A two-sample paired t test and a Wilcoxon test were computed for comparing the mean reaction times scored for "correct" and "non-correct" choices.

Results and discussion

Chicks' performance did not differ from chance level (50 %) [one-sample *t* test $t(11) = 1.448$; $p = 0.175$; mean $= 54.166$; SE $= 2.875$, see Fig. 2. Experiment 1], and no difference in reaction times between "correct" and "non-correct" trials was found [$t(11) = -1.437$, $p = 0.178$; "correct": mean $= 9.719$ s; SE $= 2.677$; "non-correct": mean $= 20.220$ s; SE $= 8.393$. Wilcoxon test two-tailed: $W(11) = 27, p = 0.380$].

Chicks did not preferentially choose between a group of two social stimuli and a group of two food stimuli, each set being simultaneously presented, even though they had proved to be motivated to respond to both types of stimuli beforehand. Lack of preferential choice was thus considered to indicate a similar motivation towards food or social target.

Experiment 2

On the basis of the results obtained in Experiment 1, a second experiment was designed to investigate whether chicks use kind information provided by imprinting and
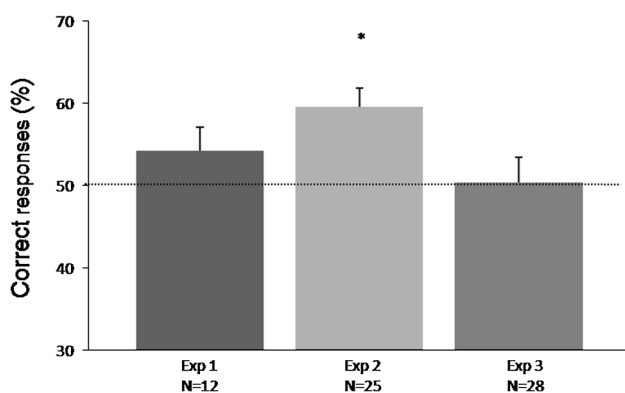

Fig. 2 Percentage of correct responses scored in each experiment (group means with SEM are shown). The correct response was to approach the screen hiding the food stimuli in Experiment 1, while in Experiments 2 and 3, the correct response was to approach the screen hiding two different stimuli. Experiment 1. Two social stimuli versus two food stimuli, simultaneously presented. Experiment 2. One stimulus presented twice versus two different stimuli presented once each (2 vs. 2 events), the stimuli were presented sequentially. Experiment 3. Two identical stimuli versus two different stimuli, simultaneously presented. The dotted line ($y = 50$) represents chance level *$p < 0.001$

food items for object individuation. Chicks were tested in a comparison between one stimulus presented twice versus two different stimuli each presented once. Previous studies demonstrated that chicks, in a discrimination task, tended to approach the larger group of either social or food stimuli (Rugani et al. 2009, 2010, 2011, 2013; Regolin et al. 2010). In this experiment, chicks were presented with an identical number of events (i.e. two events) taking place by each screen, though in one case only one object was involved, whereas in the other two objects were involved. Two objects differing in kind are for sure distinct, while the repeated presentation of one same object could either refer to two distinct objects of the same kind or to one same object presented twice. The assumption is that if chicks use kind information, they should approach the screen hiding two different objects, because difference in category would more likely suggest the presence of two distinct objects (i.e. an overall larger group). Otherwise, chicks should not manifest a preferential choice for the set comprising two different objects (given that they do not prefer either category).

Subjects, stimuli and procedure

Imprinting and testing stimuli, apparatus, general training and motivational estimations, identical to those described in Experiment 1, were repeated, and chicks were selected according to the same criteria for testing.

The chick was shown two groups of events, each taking place by a different screen. One group of events consisted in two consecutive presentations of one same stimulus (imprinting stimulus in the "social × 2 versus social–food" condition; a mealworm in the "food × 2 versus food–social" condition). The other group of events consisted of the presentation of the imprinting and of the food stimuli (consecutively). Before each trial, the two groups of objects were hidden each behind a screen (i.e. one screen hid two different objects, whereas the other hid one single object). As an example, one stimulus from one group of events was made to appear from behind one screen (where it had been previously positioned), slowly moved in front of the chick and made to disappear behind the same screen. It was then picked up once again, and the whole procedure was repeated so that the same stimulus was shown twice. The same procedure was carried out for the other group of events, with the only difference that in this case two different stimuli (i.e. one imprinting stimulus and one mealworm) were sequentially presented, once each (see Fig. 3). In this way, an equal number of events (i.e. two) took place by each screen, differing in the actual number of objects involved (either one or two).

The whole procedure lasted between 40 and 45 s. Each stimulus took 3 s to be moved from behind the screen to
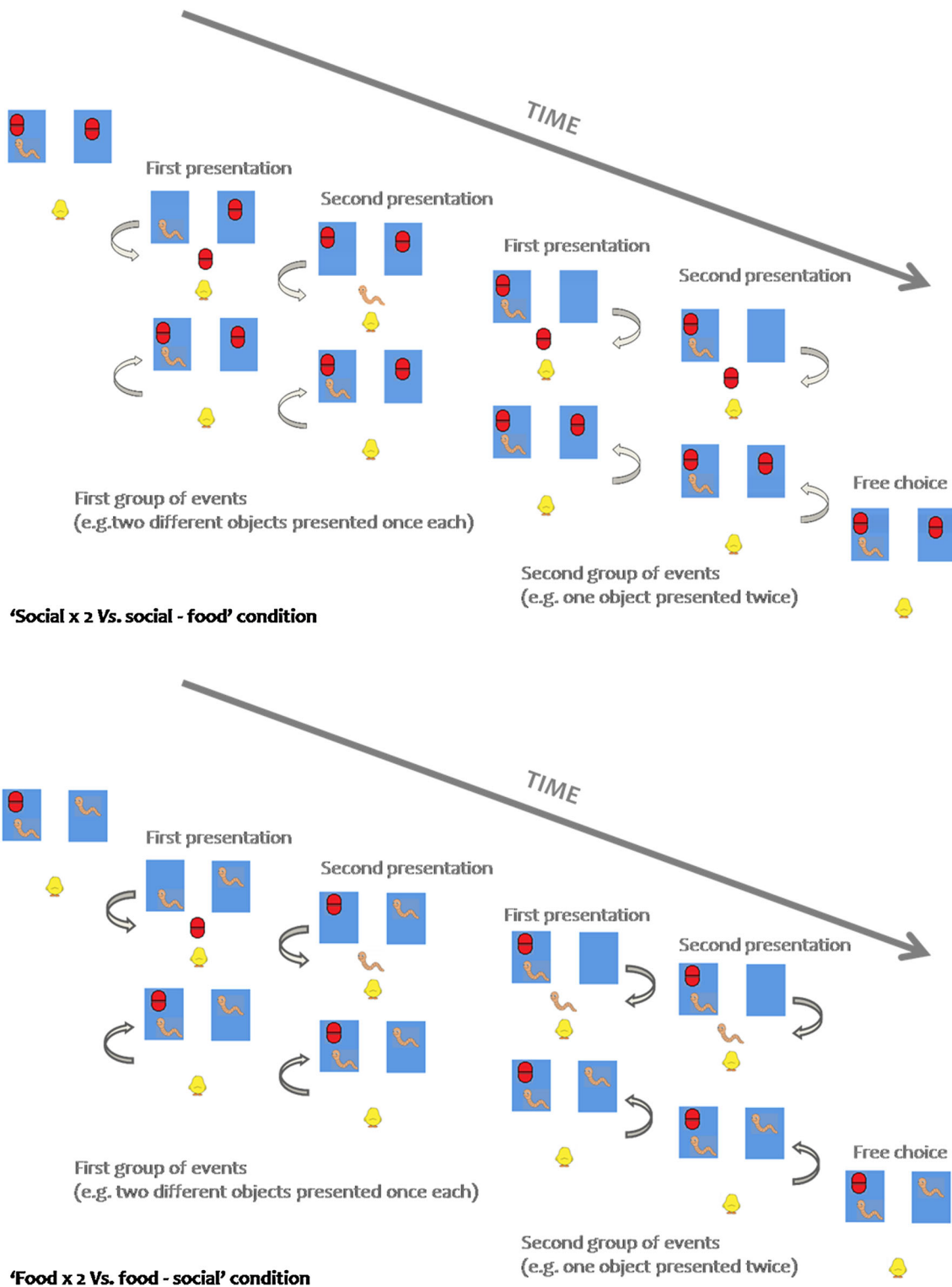
Fig. 3 Procedures for Experiment 2. Example of stimuli's presentation for the "Social × 2 versus social–food" condition and the "Food × 2 versus food–social" condition. The first group of events involved a single presentation of each of two different stimuli (a ball and a mealworm), presented one after the other. The second group of events employed the consecutive presentation of one stimulus object twice (a mealworm for "Food × 2 vs. food–social" condition and a ball for "Social × 2 vs. social–food" condition). To better illustrate the procedure, the objects are depicted in the picture above, even when they are hidden behind the screens and invisible to the chick

the front of the holding box, where it was kept for another 3 s, and then it took 3 s to be moved back behind the screen (9 s overall). About 2 s elapsed from the disappearance of one stimulus and the appearance of the next (either a same or a different) one. Immediately after the disappearance of both sets (with a delay of 5 s), the transparent partition was removed and the chick was left free to move around and search for the stimuli within the arena.

Twelve female chicks took part in the "social × 2 versus social–food" condition (i.e. one imprinting stimulus presented twice versus the two different stimuli presented once each) and thirteen female chicks took part in the "food × 2 versus food–social" condition (i.e. one mealworm presented twice versus the two different stimuli presented once each, see Fig. 3).

Each chick underwent one complete testing session of ten valid trials. The order of presentation (which event was first and which second) of the two groups of stimuli as well as the position (left–right screen) of appearance and disappearance of either set was counterbalanced as much as possible within each chick's ten testing trials.

The number of trials in which each chick chose the screen hiding two different stimuli (which was regarded as the correct choice) was considered, and percentage was computed as: (number of correct choices/10) × 100. A two-sample unpaired t test comparing percentage of correct choices scored in the "social × 2 versus social–food" condition and "food × 2 versus food–social" condition and a one-sample-two-tailed t test (to assess significant departures from chance level, i.e. 50 %) were used. A two-sample paired t test was computed for mean reaction times scored for "correct" and "non-correct" choices.

Results and discussion

No statistically significant difference in performances was found between the two conditions [two-sample unpaired t test $t(23) = -1.695$, $p = 0.103$; "food × 2 versus food–social" mean = 56.153; SE = 2.664; "social × 2 versus social–food" mean = 63.333; SE = 3.333]. Data were therefore merged, and the overall mean was compared with chance (50 %) through a one-sample t test. Chicks preferentially approached the screen hiding two different objects [$t(24) = 4.369$; $p = 0.0002$; mean = 59.600; SE = 2.196, see Fig. 2 Experiment 2]. A Chi-square analysis was used on chicks' initial performance for assessing whether chicks' choices were due to learning across trials. As chicks' behaviour in the very first test trial is usually affected by the response to the novelty of the test situation (e.g. two screens are for the very first time experienced within the arena), the first three trials were considered. A chick was regarded successful if it scored at least two correct trials within the

first three trials: this was the case for twenty chicks, the remaining five chicks were regarded as unsuccessful (they scored at least two mistakes in the first three trials). The difference (20 out of 25) was significant [χ^2 (1) = 9; $p = 0.002$]. A two-sample paired t test on the response times showed no difference between the "correct" versus the "non-correct" trials [$t(24) = 0.207$; $p = 0.837$; "correct": mean = 12.680; SE = 2.744; "non-correct": mean = 12.222; SE = 1.922].

Chicks tested in a 2 versus 2 events comparison, with one stimulus presented twice versus two different stimuli each presented once, chose the screen featuring two different stimuli, suggesting that they made use of kind information provided by imprinting and food items for individuating the group of objects. Alternatively, chicks may have chosen the group comprising an imprinting and a food object because they simply preferred a more varied group of stimuli. It could be that food plus a social object would be preferred to two pieces of food or two social objects (because it may support both social and food motivations).

Experiment 3 was designed to test this possibility.

Experiment 3

Experiment 2 supports the hypothesis that chicks can individuate objects using kind information featuring social and food items. A possible objection would be that chicks' choice of two different objects is due to a preference for the more varied group of events (two different stimuli are preferred to two identical stimuli because they support both food and social motivation). In order to test this possibility, a new group of chicks was presented with two identical versus two different stimuli. Both stimuli in a same pair were maintained simultaneously visible and could therefore be immediately individuated by the subject, before disappearing behind the screens.

No screen would be chosen above chance, if chicks preferred the higher number of stimuli, as both screens concealed two objects. If, on the other hand, chicks were attracted by a more varied set of objects, they would preferentially search the screen hiding two different objects.

Subjects, stimuli and procedure

Imprinting and testing stimuli, apparatus, general training and motivational estimation procedures, identical to those described in Experiment 1, were employed, and the same selection criteria were applied.

At test, two different experimental conditions were used: "social + social versus social + food" or

"food + food versus social + food". In each testing trial, two events were sequentially presented. One event consisted of the simultaneous presentation of two identical stimuli: either two identical imprinting stimuli (i.e. two red balls) or two food stimuli (i.e. two mealworms), according to the experimental condition. The other event consisted of two different stimuli: one red ball + one mealworm. In each event, the two stimuli were made to simultaneously appear from behind a screen, to come in front of the chick, confined in the holding box, and then made to slowly disappear behind the same screen. The whole procedure took approximately 20 s. After a delay of 5 s, the chick was let free within the arena.

A new group of 28 female chicks were tested. Half of them took part in the "social + social versus social + food" condition (i.e. two imprinting stimuli vs. one imprinting stimulus and a mealworm), whereas the other half took part in the "food + food versus social + food" condition (i.e. two mealworms vs. a mealworm and one imprinting stimulus).

The order of the events as well as which screen concealed which event were counterbalanced within each chick's testing trials. The detour of the screen hiding two different stimuli was arbitrarily chosen as correct choice, and percentages were computed, as described for the previous experiment.

Results and discussion

There was no statistically significant difference between performance in the two experimental conditions as revealed by the two-sample unpaired t test [$t(26) = -1.067$, $p = 0.296$; "social + social vs. social + food" mean = 47.142; SE = 5.389; "food + food vs. food + social" mean = 53.571; SE = 2.694]. Data were therefore merged, and the overall mean was compared with chance (50 %) through a one-sample t test. The mean percentage of correct choice did not differ from chance level [$t(27) = 0.1182$; $p = 0.9067$; mean = 50.357; SE = 3.020, see Fig. 2 Experiment 3]. A two-sample paired t test on the response times showed no difference between "correct" versus "non-correct" trials [$t(27) = -1.317$; $p = 0.198$; "correct": mean = 11.347; SE = 2.107; "non-correct": mean = 15.284; SE = 4.350].

Chicks did not prefer two different versus two identical objects, when each pair was simultaneously presented. This lack of choice eliminates the possibility that in the previous experiment, chicks chose the group of two different stimuli (sequentially presented) because of a preference for the more varied set of objects; therefore, supporting the conclusion that chicks may have used kind information provided by social and food stimuli for object individuation.

General discussion

The aim of this study was a first attempt to investigate object individuation by kind in a non-mammalian species and at a very young age. For this purpose, we employed newborns of the domestic fowl (G. gallus) as animal model. This species being precocial, newborns exhibit sensory-motor behaviours that are similar to those of the adult animals (e.g. they independently walk and feed). Newborn chicks are also capable of cognitive abilities such as using geometrical, spatiotemporal and numerical information (Vallortigara et al. 2010a, b; Vallortigara 2012). They can also learn the specific characteristics of relevant objects through imprinting: chicks can use property information provided by colour, size and shape to individuate social objects (Fontanari et al. 2011). In the present series of experiments, we took advantage of chicks' spontaneous tendency to approach the larger group of social or food stimuli (Rugani et al. 2009, 2011, 2013; Regolin et al. 2010) to test their capability of object individuation by kind. Because social stimuli and food induce different behavioural responses (i.e. affiliative responses are elicited by imprinting objects and feeding responses by food) and different levels of motivation are likely associated with them, we firstly investigated under which conditions chicks would be equally motivated to respond to food or to social stimuli with a 2 versus 2 stimuli comparison (two social stimuli vs. two food stimuli, both elements in a set being simultaneously presented). No preference for any of the two groups of stimuli was assumed to indicate equal motivation towards similar numbers of food and social attractors. In the key experiment for investigating kind information, chicks were tested with an identical number of events (i.e. two events) in a comparison between one stimulus presented twice versus two different stimuli each presented once. Chicks approached the screen hiding two different objects: difference in kind (i.e. imprinting and food items) would predict the presence of two distinct objects (i.e. of a larger group). A possible objection would be that chicks may have chosen the group comprising two different objects because of a preference for the more varied group of stimuli. This possibility was ruled out by testing chicks with the simultaneous presentation of two different versus two identical objects. These results can indicate that kind information is precociously available and spontaneously used by a bird species. Nevertheless, imprinting and food stimuli differ unavoidably in their perceptual features. Therefore, as noted by Xu (2002), it may be that subjects relied on perceptual differences for succeeding in the task, not necessarily on kind information. On the other hand, it should be noted that because social and food attractors elicit very different behavioural responses it is unlikely that chicks encode and use

perceptual differences independently from category features. Through exposure, chicks learn object properties and they associate those properties to the different kinds of elements. Once the category of the object is built, it seems ecologically advantageous to use it instead of relying on properties.

While the confound between kind membership and perceptual properties is admittedly present in our experiments, the same is true for the other papers on this topic. In the infant studies, objects to be individuated differed both in kind (e.g. duck versus truck) and in perceptual properties (e.g. shape, colour and size of duck versus truck). Thus, in principle, we cannot credit either chicks or 10-month-old infants with kind representations. We can, however, register that they behave likewise in similar test experiments. It has been argued that the use of specific relevant objects of the world, which are important for infants, emerge before than use of properties of that objects. Interestingly, infants succeeded with cross-basic-level-kind contrasts, such as a cup and a bottle or a human doll head and a dog doll head before they did with within-basic-level-kind contrasts, e.g. two shape different cups or a male doll head and a female doll head (Xu et al. 2004; Bonatti et al. 2002). Kind distinction is inductively deeper than property. A support for this emerges from differences in response times of chicks dealing with a cross-basic-level contrast, when birds are tested with social and food stimuli (in the present paper) and when birds were presented with within-basic-level contrast (i.e. imprinting objects that differed for properties such as colour, size and shape, these are data reported in a previous paper by Fontanari et al. 2011). Chicks are faster when using kind information (see Experiment 2, present paper: mean = 12.451 s, SE = 2.333) than property information (Colour: mean = 43.964 s, SE = 4.059; Size: mean = 65.239 s, SE = 5.121; Shape: mean = 30.865 s, SE = 3.974; Fontanari et al. 2011). Difference can be account for an explanation based on kind information for solving the task: chicks took longer to respond to a within-basic-level contrast (property information) than to a cross-basic-level contrast (kind information). Using kinds instead of properties would allow to save memory and improve the animal's performance.

Our data suggest that birds could be using kind information for object individuation at 2 or 3 days of life. Possible explanations based on use of property alone are intrinsic in the type of experimental paradigm we employed. On the other hand, even when objects to be individuated look exactly the same, though they differ in kind, as in the study that best controlled for the use of property (Phillips and Santos 2007), monkeys could still have learned clusters of perceptual properties that became associated with objects through experience rather than kind representation.

The present study extends evidence obtained with preverbal infants, non-human primates and dogs, suggesting that object individuation by kind may be apparent independently of language and with very limited experience of real-world objects.

Conflict of interest The authors declare that they have no conflict of interest.

Ethical standard The experiments complied with all applicable national and European laws concerning use of animals in research and were approved by the Minister of Health.

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