DO CHICKS RELY ON GEOMETRICAL OR NUMERICAL INFORMATION WHEN PECKING AT THE CENTRAL IN A LINE OF IDENTICAL BEADS ?

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Abstract

Young chicks were trained (for food reinforcement) to peck at the central in a line made of nine identical and equally space beads. During training the central bead was of a different colour, at test all beads were identical. Generalisation tests were also run with modified versions of the stimulus, obtained by changing the spacing between the single beads, so that the numerical and geometrical centres did not coincide. With the symmetrical stimulus chicks pecked the central bead significantly above chance, hence they were able of identifying such position exclusively on the base of spatial (possibly numerical) cues. With asymmetrical stimuli birds chose to peck either the numerical or the geometrical centre, depending on the distribution of inter-beads spacing, and on possible perceptual grouping.

The aim of this study was to investigate chicks' visuo-spatial abilities when dealing with conflicting numerical and geometrical (spatial) information. Many studies have shown how birds succeed in complex visual perception tasks, such as perception of subjective contours (Kanizsa, 1979; Zanforlin, 1981; Nieder & Wagner, 1999), recognition of partly occluded objects (Regolin & Vallortigara, 1995) and of illusory contours in the context of perception of pictorial information (Forkman, 1988). Domestic chicks do also possess very good visuo-spatial abilities in cognitive tasks (Regolin et al., 1994, 1995; Vallortigara & Zanforlin, 1989; Vallortigara et al., 1990). Chicks can learn to localize the central position of a closed environment lacking of distinctive cues on the base of the estimation of distances from the walls (Tommasi et al., 1997; Tommasi & Vallortigara, 2000). We used a different type of visuo-spatial task, the animal was required to discriminate the centre of a set made of nine horizontally aligned beads. Previous studies on chicks have employed a similar task in order to investigate behavioural asymmetries when responding to objects symmetrically positioned in space (Regolin, 2006). In such studies chicks succeeded in selectively pecking at the central position in a line made of equally spaced beads, although it was not clear which kind of cue (numerical or geometrical) was used by the chicks in order to locate the central object. Our aim was to replicate this study, with new stimuli putting into conflict these two information.

Method

Subjects and rearing conditions. Subjects were 42 male domestic chicks (*Gallus gallus*) obtained from a commercial hatchery when they were only few hours old. Chicks were reared socially for the first five days. On the day 6, they were isolated and then, for the duration of the experiments, the birds were kept food-deprived to between 90 and 80% of their *ad libitum* feeding weight.

Stimuli. All stimuli consisted in a rectangular white cardboard base (16 x 8 cm), onto which beads were fixed. Beads (Ø 4.7 mm) were made of glossy plastic, either red or green coloured. A first stimulus used for the shaping procedure had a single bead (either red or green) fixed in the centre of the base. On the training stimulus 9 beads were horizontally

aligned (inter-bead distance was 1 cm); they were all of identical colour except for the central bead (red vs. green or vice-versa).
Four different stimuli were used at test: Stimulus A (Fig. 1A) was identical to the training stimulus but all beads were of the same colour. Stimulus B was obtained by relocating the 5th bead (i.e. the numerical and geometrical centre) on the 6th position and by displacing the other beads at decreasing spacing (Fig. 1B). In stimuli C and D (Fig. 1) the beads were relocated so as to create, respectively, a long and a short perceptual unity. This was obtained by a larger increase in bead distances between beads 7th and 8th (Stimulus C) and 4th and 5th (Stimulus D). The resulting pattern was judged as grouping in a perceptual unit made by, respectively, 7 and 4 beads, by expert human subjects.

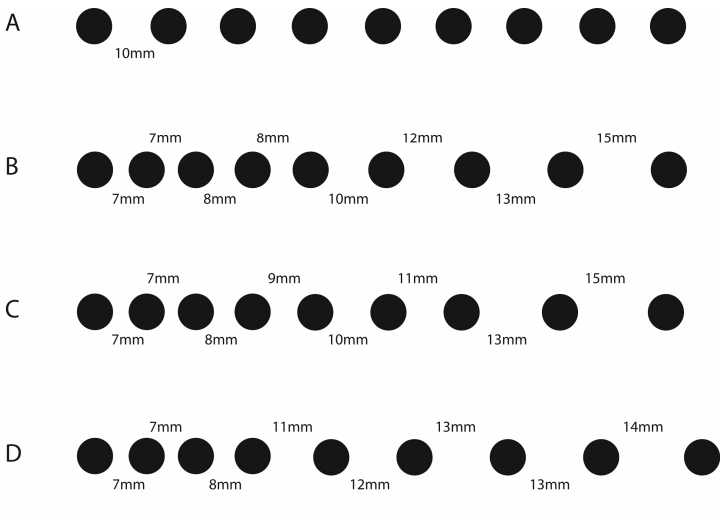

Fig. 1 Stimuli used for the test. Chicks were required to peck at the central bead.

Apparatus and procedure. The experimental apparatus (Fig. 2) consisted of a rectangular white-painted cage (33 x 38 x 60 cm) with a slit at the bottom of one of the short walls through which the food-box (6 x 6 x 12 cm) could be introduced. The food-box had a drawer that could be pushed open from outside of the cage by the experimenter in order to allow access to the food. Above the cage a unidirectional screen allowed the experimenter to watch the chick without being seen. The stimuli were fixed on the top of the food-box (at 45°).
Shaping started in the morning of day 8, after chicks had been food-deprived overnight. The chick was trained to peck at a single bead in order to open the food-box drawer and shaping was considered over after the chick had promptly pecked at the bead during 20 consecutive trials. On the same day, the chick was also trained to respond to the training stimulus: when the chick had pecked at the central bead in 17 over 20 consecutive trials the criterion was reached. Otherwise, a new training session was administered. When the chick pecked at one of the other beads, it was quickly pushed back with a mobile partition and, after 15 s, it was released for the next trial.
On day 9 (24 hours after training) all chicks were re-trained until they reached the same learning criterion as at training, then all chicks underwent a first test with the stimulus A. Then a new re-training was administered and subsequently some animals (N=24) were tested with the stimulus B and the others (N=18) were tested with stimuli C and D. Stimulus B was presented both with all red and green beads. The stimulus C and D were red only (arbitrarily chosen). Asymmetrical stimuli (B, C and D) were presented to the

birds twice, also in a left-right mirrored version. The tests consisted in 20 consecutive trials in which pecks at any bead were reinforced. All tests were video-recorded and the number of pecks assigned to each bead was scored.

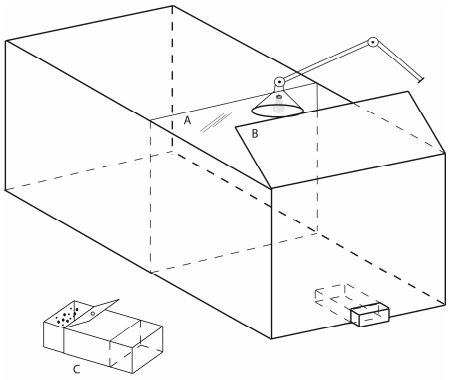

Fig. 2 Schematic representation of the apparatus. A. movable partition; B. unidirectional screen; C. food-box.

Results

All 42 chicks were tested with stimulus A (Fig. 3), where beads were equally spaced from each other and where, therefore, numerical and geometrical centre coincided.

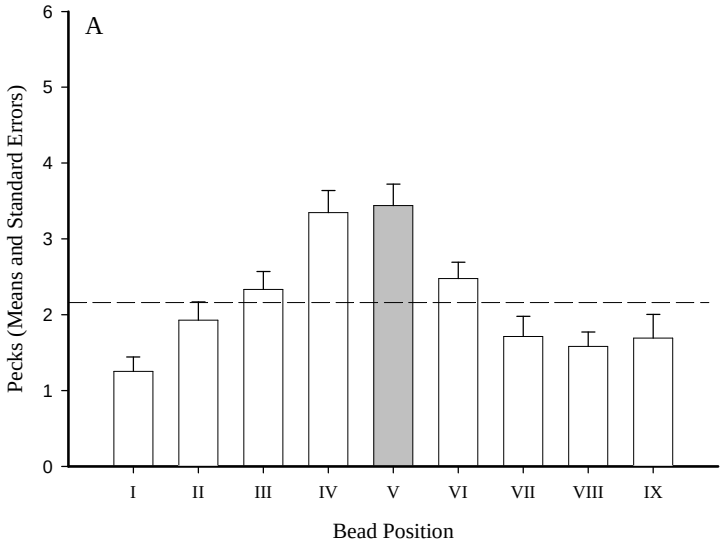

Fig. 3 Responses to stimulus A. The grey bar represents the numerical and geometrical centre. The dotted line (y=2.22) represents chance level.

Chicks pecked significantly above chance at the central bead (V: Mean±SEM=3.44±0.28; one sample t-test: t(41)=4.36, p=0.0001). All other beads were pecked either at or below chance level, with the exception of the bead at the left of the central (IV: Mean±SEM=3.34±0.29; t(41)=3.86, p=0.0004). Overall there was a slight, and not significant trend to peck more to the left side (proportion of exceeding leftwards pecks: Mean±SEM=54.44±3.14; t(41)=1.41, p=0.164). A similar bias was also described in previous works (Regolin, 2006; Diekamp et al., 2005) where birds displayed a leftward

bias in the spatial distribution of attention similar to that usually found in healthy humans (Jewell & McCourt, 2000).

Sub-groups of the chicks tested with Stimulus A, then underwent a generalisation test with one of the asymmetrical stimuli (B, C and D). Being there no difference in responses to the left and right mirrored versions of such stimuli, data from the two presentations were collapsed and mirrored for the analysis and for the graphical representation.

Twenty-four chicks were tested with Stimulus B (Fig. 4). In this case the numerical centre was represented by the 5th bead, while the geometrical one by the 6th bead.

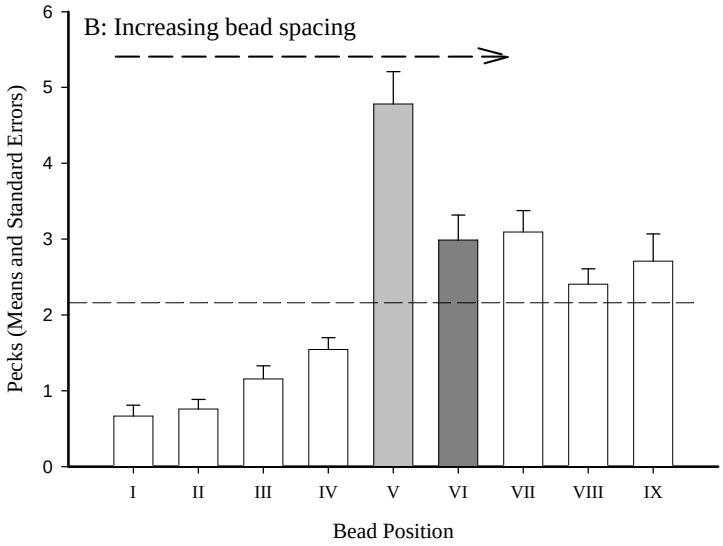

Fig. 4 Responses to stimulus B. The light grey bar represents the numerical centre, while the dark grey one the geometrical centre. The dotted line (y=2.22) represents chance level.

Chicks pecked significantly at the numerical centre (V: Mean±SEM=4.78±0.43; t(23)=5.95, p=0.0001) and chose this position above all others (V vs. VI: two sample t-test: t(46)=3.29, p=0.0019; V vs. VII: t(46)=3.30, p=0.0019). Though pecks to the 6th and 7th bead were also above chance (VI: Mean±SEM=2.99±0.33; t(23)=2.33, p=0.0287; VII: Mean±SEM=3.09±0.28; t(23)=3.10, p=0.005).

Birds seemed though to chose the numerical centre above others. It is worth notice that the numerical centre in this stimulus (Fig. 1B) represents to the human subject the end of a perceptual unit. To check for the role of such interfering cue in triggering chicks' responses, eighteen chicks tested with stimulus A were then re-tested with stimulus C (Fig. 5). In stimulus C the geometrical centre is again represented by the 6th bead (the 5th is of course the numerical centre) but now the end of a grouping perceptual unit is represented by the 7th bead.

Chicks chose the 6th bead (VI: Mean±SEM=4.3±0.52; t(17)=2.92, p=0.0061) but also the 9th (IX: Mean±SEM=4.97±0.57; t(17)=4.82, p=0.0002). There was a significant difference between choices of the geometrical and numerical centre (V vs VI: two sample t-test: t(34)= 2.92, p=0.0061) and the numerical centre was not pecked above chance (V: Mean±SEM=2.5±0.33; t(17)=0.85, p=0.41). It seems that chicks relied on spatial cues in order to identify the "central" bead.

There was an unusually large number of pecks on the 9th bead, we have no interpretation for this outcome.

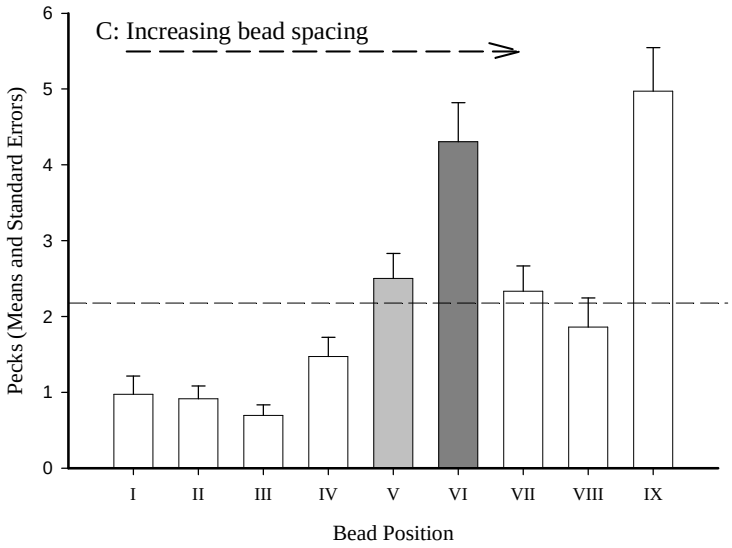

Fig. 5 Responses to stimulus C. The light grey bar represents the numerical centre, while the dark grey one the geometrical centre.

Another group of eighteen chicks was re-tested with stimulus D, where the geometrical centre did not coincide with any bead, but was closest to the 6th bead. The end of the perceptual unit in this case was not represented by the numerical or geometrical centre but by the 4th bead.

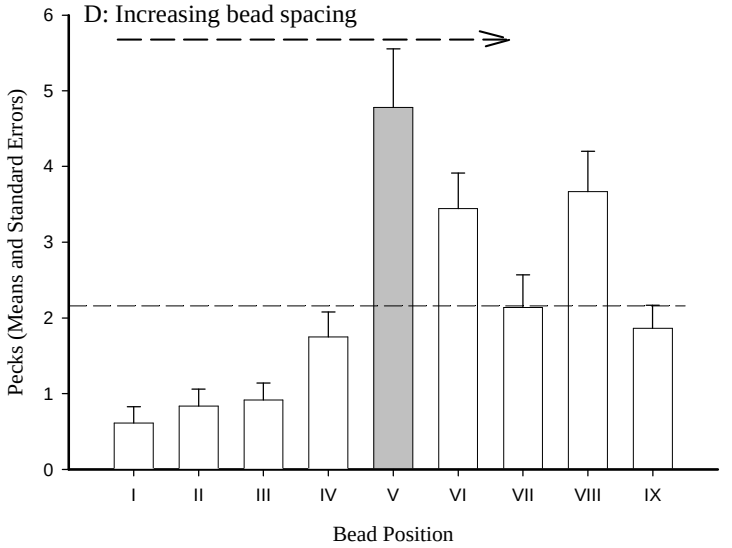

Fig. 6 Responses to stimulus D. The light grey bar represents the numerical centre.

Data showed that birds pecked more at the numerical centre (V: Mean$\pm$SEM=4.78±0.78; t(17)=3.28, p=0.004) but also to the 6th and 8th bead (VI: Mean$\pm$SEM=3.44±0.47; t(17)=2.22, p=0.018; VIII: Mean$\pm$SEM=3.67±0.53; t(17)=2.74, p=0.014). There was no difference in choice of 5th (numerical) and 6th (geometrical) beads (t(34)=1.47, p=0.1504).

Discussion

Week-old chicks were trained to peck at the central in a series of identical beads, horizontally aligned and equally spaced, and then tested with different versions of the training stimulus, in order to investigate whether the ability to identify the centre depended on numerical or geometrical (spatial) information. With the equally spaced stimulus (A) chicks easily identified the central bead. Responses to the asymmetrical stimuli were more heterogeneous and depended on inter-bead spacing distribution and by the resulting perceptual grouping of some beads. With stimulus B chicks chose the numerical centre, that was also the end of a gestalt. Displacing such perceptual grouping end resulted in chicks choosing the centre which was closest to it: i.e. the geometrical in the case of stimulus C and the numerical in the case of stimulus D.
Further investigation is needed in order to disentangle the three factors that seem to affect chicks' responses to the asymmetrical stimuli (B, C and D), i.e., the numerical centre, the geometrical centre and the perceptual grouping due to different inter-bead spacing.

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