Exploring early self-referential memory effects through ownership

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The self-reference effect (SRE) is the reliable memory advantage for information encoded about self over material encoded about other people. The developmental pathway of the SRE has proved difficult to chart, because the standard SRE task is unsuitable for young children. The current inquiry was designed to address this issue using an ownership paradigm, as encoding objects in the context of self-ownership have been shown to elicit self-referential memory advantages in adults. Pairs of 4- to 6-year-old children ($n = 64$) sorted toy pictures into self- and other-owned sets. A surprise recognition memory test revealed a significant advantage for toys owned by self, which decreased with age. Neither verbal ability nor theory of mind attainment predicted the size of the memory advantage for self-owned items. This finding suggests that contrary to some previous reports, memory in early childhood can be shaped by the same self-referential biases that pervade adult cognition.

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A robust feature of adult cognition is the ‘self-reference effect’ (SRE) in memory (Rogers, Kuiper & Kirker, 1977; Symons & Johnson, 1997), the memory advantage for information encoded in relation to the self over material encoded about others. However, there is little evidence of early self-referential memory biases, with an adult-like SRE reported to develop between 7 and 10 years (Halpin, Puff, Mason & Marston, 1984; Hammen & Zupan, 1984; Pullyblank, Bisanz, Scott & Champion, 1985). Given the ubiquitousness of the influence of the self on adult cognition, it seems a worthwhile goal to chart the emergence of early self-referential memory biases.

The scarcity of evidence for SREs in early childhood may be due to the tendency for developmental researchers to focus on the standard adult SRE paradigm (Symons & Johnson, 1997), in which participants encode information through abstract self- or other-evaluation.

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(e.g., ‘Are you creative?’ versus ‘Is Brad Pitt modest?’). Young children are not generally included in such studies because they cannot reliably evaluate abstract character traits. However, a well-developed sense of self is apparent by early childhood (Lewis, 2003), and children of 3 and 4 years do show some self-processing biases such as the enactment effect (enhanced memory for self-produced actions; Ross, 2008). This raises the question of whether early self-referential memory effects may be found, given more appropriate paradigms.

Intriguingly, a study that did not involve evaluating the self or other but rather, associating pictures of the self or other with an object, showed a SRE in children as young as five (Sui & Zhu, 2005). In Sui and Zhu’s task, children were presented with a cartoon figure incorporating a photograph of their own or another child’s face. In each trial, the figure was shown pointing to an object. The child’s task was to determine whether the figure was presented with their own or the other child’s face (i.e., ‘is it ‘me’ or ‘other’ who is pointing to the object?’). After this encoding phase, the children’s memory for the objects was tested using free recall and source memory measures. Across two experiments, 5-year-old children were found to show a free recall advantage for items presented with the self-image.

While this study suggests that young children might demonstrate self-referential memory biases if age-appropriate paradigms were utilized, it also raises some questions regarding the development of the effect. In Experiment 1 of Sui and Zhu’s study, 4-, 5- and 10-year-old children were tested but only 5-year-olds showed a SRE in memory. The authors suggest that the absence of a SRE in 4-year-old children may reflect a relatively poorly defined self-concept, although there was no independent measure of self-concept to support this explanation. They also speculate that SREs on memory may be dependent on the development of verbal labelling strategies, which can aid recall from around 6 years (Baker-Ward, Ornstein & Holden, 1984). Regarding the older children, the authors suggest that low task demands prevented self-other memory differences from emerging. In Experiment 2, they therefore increased task difficulty and found a self-referential memory advantage in both 5- and 10-year-olds (4-year-olds were not tested). Sui and Zhu conclude that children of 5 years and older can show SREs in free recall, given sufficient task difficulty.

Sui and Zhu’s pattern of results suggests that further exploration of the early emergence of self-referential memory effects is merited. The current study is designed to meet this end, following Sui and Zhu’s approach of using picture-based, concrete tasks, but extending their research in three important ways. First, the developmental trajectory of SREs across the seemingly critical period of 4–6 years will be examined in detail. Second, additional measures of cognitive development (verbal ability and theory of mind [ToM] understanding) will be included to examine the influence of these potentially task-relevant factors on any developmental trends. Third, the task requirement will be changed from one of face identification (where the focus is the person, not the object) to a task in which the relationship between the referent (i.e., the person to whom the stimulus is referenced) and object is crucial at encoding. This shift is important because if younger children (i.e., 4-year-olds) are more engaged with the objects at encoding, then they may show self-referential encoding advantages in line with older children.

The paradigm selected in the current inquiry to create this self-object association at encoding was an ownership task (Cunningham, Turk, MacDonald & Macrae, 2008; Cunningham, Van den Bos & Turk, 2011; Van den Bos, Cunningham & Turk, 2010). Owned objects comprise a unique class of stimuli, being treated as psychological extensions of self and becoming subject to self-referential processing biases (Beggan,
1992; Belk, 1988; James, 1890). Accordingly, encoding items in the context of imagined self-ownership lead to better item memory than ownership by others (Cunningham et al., 2008). This ‘ownership effect’ is considered to be a form of SRE because it is thought to arise through the creation of a self-relevant encoding context.

Examining ownership effects seems a particularly appropriate method of exploring self-referential processing in early childhood, because very young children understand the concept of ownership and afford it a high social importance (Fasig, 2000; Furby, 1980; Hay, 2006; Smiley & Johnson, 2006). For example, from around 18 months to 2 years, children begin to use first, second and third possessive pronouns (e.g., mine/yours/Daddy’s) appropriately in social interaction and possession disputes (Hay, 2006; Ross, 1996). By at least 4 years, children spontaneously infer ownership from first possession in stories (Friedman & Neary, 2008) and have a well-established understanding of ownership as separate from current possession (Fasig, 2000; Ross, 1996). During early childhood, ownership also has a considerable social impact, accounting for a high proportion of sibling and peer disputes (Furby, 1980; Ramsey, 1987; Shantz, 1987). Further, children’s understanding of ownership is linked to their early self-concept development, with toddlers who demonstrate ownership concepts more likely to be able to self-describe and evaluate (Fasig, 2000). Using an ownership paradigm to explore children’s developing self-referential encoding therefore seems a logical step.

Adapting Cunningham et al.’s (2008) procedure, we asked 4- to 6-year-old participants to sort pictures of toys into self-owned and other-owned baskets. As with the standard SRE paradigm, this design allows self-referent and other-referent processing to be directly compared, so that any differences between them can be ascribed to self-specific operations. It was expected that, following adults’ memory advantage for self-owned items, children would show a recognition advantage for items encoded as self-owned over those owned by others.

The age range in the sample includes the period in which Sui and Zhu reported no SREs (4 years), as well as the earliest age at which they found a self-referential memory advantage (5 years). Six-year-olds were also included so that the range allowed an examination of the developmental trajectory of the SRE. Based on Sui and Zhu’s work, as well as that of researchers using the standard trait evaluation paradigm (Halpin et al., 1984; Pullyblank et al., 1985; Ray et al., 2009), it is predicted that the children will show an increasing memory advantage for self-owned items with age.

In addition to the ownership task, the children completed two tests designed to track developmental changes that may influence levels of self-referential encoding. The first was verbal ability, as assessed by receptive vocabulary (the British Picture Vocabulary Scale [BPVS], Dunn, Dunn, Whetton & Pintilie, 1982). BPVS performance correlates highly with general cognitive ability as well as verbal development (Dunn et al., 1982). If self-referential memory advantages reflect an increase in verbal labelling or strategic encoding (Sui & Zhu, 2005), then receptive vocabulary may be predictor of self-memory performance. The second was a test of ToM ability, in which children are asked about a series of increasingly complex ToM-dependent scenarios (Jarrold, Butler, Cottington & Jimenez, 2000; Sparrevoehn & Howie, 1995). This test was included because ToM ability develops markedly between 3 and 5 years, reflecting an increasing capacity to consider mental states of both self and others (for review see Wellman, Cross & Watson, 2001). ToM ability may therefore be relevant to any developmental trends in patterns of self-referent and other-referent processing by children in the current sample.
Method

Participants
Sixty-four children aged between 4 and 6 years (53.1% boy, mean age 64.0 months) participated in the study, with the written consent of their parent or guardian. The sample comprised twenty-four 4-year-old, twenty-one 5-year-old and nineteen 6-year-old pupils of local nursery and primary schools. The research was conducted in accordance with the guidelines and approval of the University of Aberdeen’s Psychology Ethics Committee.

Procedure and stimulus materials
The children were tested in pairs by two experimenters in a quiet school area. The children sat side-by-side opposite one experimenter at a table. Two baskets (one red and one yellow) were placed together in front of the children. Following the procedure of Cunningham et al. (2008), each child was asked to imagine that they owned the basket in front of them. They were then told, ‘I have some picture cards here. These cards are very special, they have pictures of toys on them. Now let’s pretend that all the toys that go into the red basket belong to [child A’s name], and all the toys that go into the yellow basket belong to [child B’s name]’.

The children were asked to take turns to put the cards into the appropriate basket, by matching the colour of a border around the card with the colour of the basket. This design ensured that the children had to attend to items that went into both baskets, and that children encoded all the items in the context of ownership by one referent (i.e., self or other). They were asked not to talk during the sorting task. The experimenter held up each card individually at an equal distance from each child, named the pictured toy, and handed the card to one of the children to sort. The child then put the card face-down in the correct basket.

The set of picture cards comprised 84 laminated photographic images of toys (e.g., teddy bear, toy car – see Table 1 for full list) pictured on a 90 × 90 mm white background, surrounded by a 10 mm red or yellow border. Pilot testing (n = 10) confirmed that the toys and their verbal labels were highly familiar to 4-, 5-, and 6-year-old children. The toys depicted on the cards were divided into three equivalent lists, matched for toy type (e.g., outdoor toys, cuddly toys), syllabic length and stereotypic owner gender. The use of these lists as red-bordered cards, yellow-bordered cards and foils for the subsequent recognition test was counterbalanced across participants. The order of the cards within each set was randomized (by shuffling), but the sets were prearranged so that each child sorted half of the cards that were put in their own basket, and half that went into the other person’s basket.

Once all the cards had been sorted, a surprise recognition memory test was administered. Each experimenter took one child to a separate table, where they were shown pictures of all 84 toys (i.e., 28 self-owned, 28 other-owned and 28 previously unseen) printed on un-bordered cards. Each card was shown to the child and verbally labelled, and the child was asked whether they had seen the toy in the sorting task. Presentation order was randomized and the children’s responses were manually recorded.

1 To rule out any effects of basket proximity, an additional thirty participants aged 4–6 years (36.7% boy; mean age, 58.7 months) completed the sorting task without any basket ownership. The experimental procedure was identical, with a red and yellow basket being placed on the table in front of the children, but they were not asked to imagine that they owned the contents of either basket. The recognition data from these participants revealed no effect of basket proximity on memory performance, F(1, 29) = 0.13, p = .717, ηp² = .005.
by the experimenter. On completion of the recognition test, each child was debriefed, thanked and returned to the classroom. During debriefing, the experimenter asked the child about the ownership task and was satisfied that all the children had fully understood the instructions.

Participants were seen individually for a second time to complete the BPVS (Dunn et al., 1982) and a series of ToM tasks (Jarrold et al., 2000; Sparrevohn & Howie, 1995). Most participants completed the BPVS within 2 weeks of the original testing session, but 10 participants were seen 6 weeks later due to school holidays and timetabling issues. (For these participants, age in months is reported for their age at time of ownership task completion. However, the standardized receptive vocabulary score was calculated according to their age at the time of BPVS completion.)

After completing the BPVS, each child’s ToM ability was assessed using a series of six tasks taken from Jarrold et al. (2000; Sparrevohn & Howie, 1995). These tasks are designed to test the ability to understand, in order of delivery, (i) inferred belief, (ii) not-own belief, (iii) explicit false belief, (iv) own false belief, (v) another’s false belief and (vi) second-order false belief (see Appendix A for full procedural details). The task delivery order reflects a sequential increase in difficulty. ToM score was calculated by summing each participant’s scores on the six individual ToM tasks (Jarrold et al., 2000).

<table>
<thead>
<tr>
<th>List 1</th>
<th>List 2</th>
<th>List 3</th>
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<tbody>
<tr>
<td>Arm bands</td>
<td>Bag</td>
<td>Aeroplane</td>
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<tr>
<td>Barbie doll</td>
<td>Balloons</td>
<td>Ball</td>
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<td>Blackboard</td>
<td>Bob the Builder</td>
<td>Bike</td>
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<td>Bouncy castle</td>
<td>Buggy</td>
<td>Boat</td>
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<td>Bucket and spade</td>
<td>Building blocks</td>
<td>Books</td>
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<td>Cash register</td>
<td>Climbing frame</td>
<td>Buzz Lightyear</td>
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<tr>
<td>Dartboard</td>
<td>Crayons</td>
<td>Camera</td>
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<td>Elephant</td>
<td>Doodles the dog</td>
<td>Car</td>
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<td>Felt-tipped pens</td>
<td>Helicopter</td>
<td>Clown</td>
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<td>Giraffe</td>
<td>Lion</td>
<td>Dinosaur</td>
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<td>Kitchen</td>
<td>Marbles</td>
<td>Dolls’ house</td>
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<td>Lego</td>
<td>Mr Potato Head</td>
<td>Drums</td>
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<td>Little Mermaid</td>
<td>Paints</td>
<td>Etch-a-sketch</td>
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<td>Monkey</td>
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<td>Mr Incredible</td>
<td>Robot</td>
<td>Go kart</td>
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<td>My Little Pony</td>
<td>Roller skates</td>
<td>Guitar</td>
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<td>Paddling pool</td>
<td>Roly Mo</td>
<td>Jack-in-the-box</td>
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<td>Peter Rabbit</td>
<td>Shark</td>
<td>Jigsaw puzzle</td>
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<td>Playdoh</td>
<td>Shopping trolley</td>
<td>Keyboard</td>
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<td>Power Ranger</td>
<td>Skipping rope</td>
<td>Kite</td>
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<td>Rocking horse</td>
<td>Sledge</td>
<td>Mickey Mouse</td>
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<td>Scooby Doo</td>
<td>Spiderman</td>
<td>Piggy bank</td>
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<td>Scooter</td>
<td>Sunglasses</td>
<td>Skittles</td>
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<td>Shape sorter</td>
<td>Tea set</td>
<td>Snow white</td>
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<td>Superman</td>
<td>Tools</td>
<td>Teddy</td>
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<td>Watch</td>
<td>Tractor</td>
<td>Thomas the Tank Engine</td>
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<tr>
<td>Wendy house</td>
<td>Trampoline</td>
<td>Tigger</td>
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<tr>
<td>Yo–yo</td>
<td>Turtle</td>
<td>Winnie the Pooh</td>
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Following the completion of the six ToM tasks, the child was thanked, debriefed and returned to the classroom.

**Results**

One 4-year-old participant did not complete the memory test, and two more were removed from the analysis because their tendency to produce false alarms (i.e., to give ‘Old’ responses to New items) was unusually high (72.1% and 78.6%), suggesting a tendency to say ‘Old’ regardless of item memory. Excluding these participants, false alarms comprised 7.75% of ‘Old’ responses. In addition, one 6-year-old participant was removed because her memory data fell three standard deviations from the mean. These exclusions left twenty-one 4-year-olds (66.7% boy; mean age, 52.8 months; $SD$, 2.6 months), twenty-one 5-year-olds (52.4% boy; mean age, 64.9 months; $SD$, 3.6 months) and eighteen 6-year-olds (44.4% boy; mean age, 77.7 months; $SD$, 3.1 months) in the analysis.

Memory performance for both self-owned items and other-owned items was transformed into the discrimination score $A'$, which indicates participants’ ability to truly distinguish between Old and New items, regardless of response bias (Snodgrass, Levy-Berger & Haydon, 1985). The $A'$ transformation is appropriate for providing a measure of discrimination when false alarm rates are heterogeneous, as in the current sample (e.g., false alarm rate ranged from 18.0% in the 4-year-olds to 3.6% in the 6-year-olds). There was no effect of acting on the cards (i.e., self-moved item memory did not differ from other-moved item memory), $t(59) = 0.53, p = 0.601$, so action was not included as a factor. Two analyses were conducted: an ANCOVA exploring the difference between memory for items encoded as self- and other-owned, and a regression analysis to explore the whether age, ToM or verbal ability predicted any self-referential memory advantage.

The $A'$ scores were submitted to a repeated-measures analysis of variance (single factor: Owner – self or other). Age in months was included as a covariate to allow an examination of the correlation between age and memory for self- and other-owned items, as well as the interaction between these variables. The ANCOVA revealed a significant effect of owner, $F(1, 58) = 6.72$, $p = .012$, $\eta^2_p = .104$, with participants correctly recognizing more self-owned than other-owned items. There was also a main effect of age, $F(1, 58) = 5.31, p = .025, \eta^2_p = .084$, with $A'$ scores significantly increasing with age, $r(60) = .29, p = .025$. The interaction between owner and age in months was also significant, $F(1, 58) = 4.40, p = .040, \eta^2_p = .070$, indicating that the effect of ownership differed across the age range.

A regression analysis was conducted to explore the influences of the three IVs (age, ToM and verbal ability) on the magnitude of the ownership effect. The memory advantage

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2 Male and female participants did not differ in their pattern of memory performance (Gender main effect: $F(1, 58) = 0.4, p = .515, \eta^2_p = .007$; Gender × owner interaction: $F(1, 58) = 0.04, p = .837, \eta^2_p = .001$). Scores were therefore collapsed across gender.

3 Full details of false alarm rate, recognition memory performance and test scores broken down by age (in years) are listed in Appendix B. As can be seen from the raw recognition rates, the data were not influenced by ceiling effects (mean raw recognition score by 4-year-old participants: 75.3%).

4 If ‘$H$’ is the hit rate and ‘FA’ the false alarm rate, the following formula is used to calculate $A'$: (i) If $H$ is greater than $FA$, then $A' = 0.5 + ((H - FA) / (1 + H - FA)) / 4 H (1 - FA)$. (ii) If $FA$ is greater than $H$, then $A' = 0.5 - ((FA - H) / (1 + FA - H)) / 4 FA (1 - H)$. (iii) If $H$ and $FA$ are equal, $A' = 0.5$. An $A'$ score of 1.0 indicates correct responses to all Old and New items, whereas scores of 0.5 or less suggest that participants are not able to discriminate Old from New items. Thus, higher scores indicate better Old–New discrimination.
for self-owned items (i.e., self-owned $A'$ score — other-owned $A'$ score) was calculated. This ‘self-owned advantage’ score was entered as the dependent variable in a linear regression analysis, in which age (in months), verbal ability and ToM score were included as IVs. Verbal ability was calculated by transforming raw BPVS performance to an age-dependent standardized score (Dunn et al., 1982).

Hierarchical regression analysis was conducted with age entered last, so that the influence of age could be examined while controlling for any effects of ToM and verbal ability. This analysis revealed that age in months was the only significant predictor of the self-owned advantage ($\beta = -.28, R^2 = .077, t = -2.11, p = .040$). Neither verbal ability ($\beta = -.06, t = -0.42, p = .677$) nor ToM score ($\beta = .07, t = 0.54, p = .595$) predicted the memory advantage for self-owned items.

The predictive effect of age on the memory advantage for self-owned items reflected a *moderate* tendency for the memory advantage for self-owned items to decrease across the age range, with age accounting for 7.7% of the variance (Figure 1). To further examine this pattern, the relationship between age (in months) and $A'$ scores was examined separately for self- and other-owned items. This revealed that memory for other-owned items increased significantly with age, $r(60) = .33, p = .011$, while there was only a marginal tendency for self-owned item memory to increase with age, $r(60) = .24, p = .063$. This pattern explains why the interaction between the referent and age was found, as the effect of referent was stronger in the younger than the older children.

**Discussion**

The results of the current inquiry reveal a clear memory bias in young children for objects encoded in the context of self-ownership, over those assigned to ownership by others. This pattern replicates previous adult research (Cunningham et al., 2008; Van den Bos et al., 2010), confirming that the impact of self-ownership mirrors self-referential encoding biases even when the ownership is hypothetical, temporary and arbitrarily
assigned. The finding is especially interesting because of the previous scarcity of evidence for SREs in early childhood. That an ownership effect was found in children as young as four suggests that self-referential memory differences emerge before they are reliably assessed using the standard, evaluative SRE paradigm.

Previous suggestions that the SRE does not emerge until late childhood are based on a trait evaluation paradigm, which requires the processing of abstract character traits with reference to self-knowledge (Halpin et al., 1984). The SRE elicited by this task is argued to result from the organization and enrichment of material evaluated with reference to the self-concept, as this provides a rich and accessible knowledge framework (Conway & Dewhurst, 1995; Conway, Dewhurst, Pearson & Sapute, 2001; Klein & Kihlstrom, 1986; Klein & Loftus, 1988; Symons & Johnson, 1997; Van den Bos et al., 2010). The developing self-concept and growing body of self-knowledge across childhood therefore accounts for the reported increase in SRE with age (Halpin et al., 1984; Ray et al., 2009; Pullyblank et al., 1985).

Unlike the trait evaluation paradigm, Sui and Zhu’s (2005) concrete processing task did not require abstract self-knowledge to be applied at encoding, and accordingly, children from 5 years of age were found to show a SRE. However, 4-year-olds in the Sui and Zhu study did not show any self-other memory difference. It is possible that unlike the current inquiry, 4-year-old children in Sui and Zhu’s experiment were not engaged with the to-be-remembered objects, as they were required simply to identify the referent rather than link the referent with the object in any meaningful way. In contrast, observation of younger children in the current paradigm suggests that they frequently became very engaged in the relationship between the object and the referent (e.g., spontaneously responding ‘Yes – I like that one!’). The current findings demonstrate that with a good level of task engagement, very early self-referential processing biases can be found.

Consistent with the explanation of the adult SRE, there is scope for elaboration of incoming stimuli in the ownership paradigm, with familiar items activating associated extant knowledge and autobiographical memories. However, unlike the SRE task, these associated memories could be activated by stimuli in both ownership conditions. For example, an object presented in the ownership task (e.g., tea set) could activate an autobiographical memory (‘I played with one of them at nursery’) or semantic knowledge whether the object is assigned to ownership by self or the other participant. In contrast, a presentation in the standard SRE task (e.g., ‘is Brad Pitt kind?’) requires information about only the specified referent to be activated. This feature of the ownership task explains why the children’s increasing object knowledge (i.e., vocabulary scores, along with an assumed increase in toy experience) with age did not lead to an increasing ownership effect in the current inquiry.

Although the potential for elaboration does not distinguish the encoding of self- and other-owned objects in the ownership task, there is a difference in the likelihood that such elaboration will occur in the two conditions. Items encoded as self-owned acquire personal salience and are likely to evoke automatic responses associated with cues of self-relevance such as increased attention (Bargh, 1982; Cherry, 1953; Gray, Ambady, Lowenthal & Deldin, 2004). Indeed, recent neuroimaging evidence suggests that increases in both visuo-spatial and executive attention to an object are characteristic responses to cues of self-ownership (Turk, van Bussel, Brebner, Toma, Krigolson & Handy, 2011; Turk, van Bussel, Waiter & Macrae, 2011). Thus, in the current study, increased attention to self-owned items is likely to be the mechanism through which self-ownership results in enhanced memory.
An interesting pattern to emerge from the current inquiry was that the size of the memory advantage for self-owned items decreased between the ages of 4 and 6 years. Neither aspect of cognitive development measured in the current inquiry (i.e., verbal ability and ToM ability) was related to the size of the self-referential advantage; only age was a significant predictor. This pattern may reflect to the extent to which self-owned items attracted the attention of the children, as there are reasons to expect that younger children in the sample would be more engaged in the ownership element of the task. The social importance of ownership is at its height in early childhood, when arguments regarding possession dominate social interactions (Furby, 1980; Ramsey, 1987; Shantz, 1987). Further, young children are more object-focused than older children in terms of visuo-spatial memory (Lange-Küttner, 2010a,b), suggesting that objects play a particularly important role in memory at this early stage. Finally, the toys in the current inquiry were designed to be recognized by all participants, so may have been of comparatively little interest to more mature children. These points combine to suggest that the younger children in the current sample were more engaged in the object-ownership element of the encoding task, leading to a greater memory advantage for the self-owned objects. Therefore, while older children showed better memory overall, younger children were more biased towards preferentially encoding their own toys.

Related to this point, closer examination of the pattern of memory for self-owned and other-owned items revealed that the main reason for the developmental pattern was that memory for other-owned items increased more than memory for self-owned items. Interpretation of this pattern is difficult because overall memory would be expected to increase across this age range (i.e., 4–6 years), but because of the relatively high memory for self-owned items in the younger children it is possible that there is more scope for the improvement in memory for other-owned items.

The fact that ToM was not a significant predictor of the size of the memory advantage for self-owned items is an interesting null effect, especially as an increase in other-owned object memory seemed to underlie the age-related reduction in the ownership effect. Self-owned object memory also increased with age but this trend did not reach significance. This pattern suggests that the older children were less exclusively focused on their own objects and were more likely to use their stored knowledge to elaborate all objects, a tendency that might intuitively be expected to relate to ToM development. This null finding highlights the critical difference between the psychological concept of egocentrism outlined by Piaget (1926/1959) and incorporated in ToM tasks (i.e., difficulty in taking different perspectives and understanding that others have different beliefs), and the conventional use of the term as referring to extreme personal focus (Kesselring & Müller, 2011). In the current inquiry, Piagetian egocentrism and ToM ability did not impact on levels of self-referential encoding, but there did appear to be a more exclusive focus on self-referential objects in the younger children. Further research is required to more fully examine understand the effects of these factors in driving early self-referential memory processes.

In conclusion, the current findings show that even in early childhood, encoding items in the context of self-ownership elicits a memory advantage. That this effect was found in young children suggests that self-referential memory effects can emerge considerably earlier than indicated by previous SRE-based research. This provides an exciting insight into the early influence of the developing self on cognition.
Acknowledgements

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References


Appendix A

Theory-of-Mind Task Protocol (adapted from Jarrold et al., 2000).

(i) Inferred belief
‘This is Emma [show picture]. This morning Emma saw her pencil case on the desk [show picture of desk], not on the shelf [show picture of shelf]. Now Emma wants her pencil case. Where will she look for it?’
[correct answer: desk]

(ii) Not-own belief
‘This is Paul [show picture]. Paul wants to find his dog. It might be hiding in the house [show picture of house] or in the garden [show picture of garden]. Where do you think Paul’s dog is hiding?’ [child answers]. ‘That’s a good guess. Paul thinks his dog is in the [other location]. Where will he look for his dog?’
[correct answer: other location]

Explicit false belief
‘This is Andrew [show picture]. Andrew wants to find his kitten. Andrew thinks his kitten is in the kitchen [show picture of kitchen], but it’s really in the bedroom [show picture of bedroom]. Where will Andrew look for his kitten?’
[correct answer: kitchen]

Own false belief
‘Here is a Smarties tube [show Smarties tube]. What do you think is in here?’
[child answers: Smarties] ‘No, look, it’s got Lego bricks in it [show Lego bricks and then close lid]. What is really in here?’ [child answers: Lego] ‘When I first showed you the box, what did you think was inside it?’
[correct answer: chocolates]

Other’s false belief
‘Here is Rachel [show doll]. She has got a sweetie, look. She is going to put her sweetie under the blue cup [put sweetie under cup]. Now Rachel is going out; she will come back for her sweetie later [act out with doll]. Now here comes Sarah [show second doll]. Sarah is naughty and is going to move the sweetie. Look, she’s put it under the yellow cup [move sweetie to under yellow cup]. Now Sarah goes away [act out with doll]. Ah, here comes Rachel, she wants to get her sweetie now. Where does Rachel think the sweetie is?’
[correct answer: blue cup]
Second-order false belief

‘Here are Sarah and Michael in the park [show dolls and act out following scenario]. Along comes the ice-cream man [show ice cream van with man at window]. Michael would like an ice-cream, but he has left his money at home. He is very sad. ‘Don’t worry,’ says the ice-cream man, ‘you can go home to get your money and buy some ice-cream later. I’ll be here in the park all afternoon.’ So Michael goes home.

Now the ice-cream man says to Sarah, ‘I am going to drive my van to the church to see if I can sell my ice-cream there.’ The ice-cream man drives to the church, but on his way he passes Michael’s house. Michael sees him and asks him where he is going. The ice-cream man says, ‘I am going to sell my ice-cream outside the church’ and then drives off. Now Sarah goes home to her house and then goes over to Michael’s house. She knocks on the door and asks Michael’s mum if Michael is in. ‘No,’ says Michael’s mum, ‘he’s gone to buy an ice-cream.’ Where does Sarah think that Michael has gone?’

[Correct answer: the park]

Appendix B

Test scores and raw memory performance of 4-, 5- and 6-year-olds. (A’ difference score calculated by subtracting the A’ score for other-owned items from the A’ of self-owned items).

<table>
<thead>
<tr>
<th></th>
<th>4-year-olds</th>
<th>5-year-olds</th>
<th>6-year-olds</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean (SD) Age (months)</strong></td>
<td>52.8 (2.6)</td>
<td>64.9 (3.6)</td>
<td>77.7 (3.1)</td>
</tr>
<tr>
<td><strong>Mean (SD) ToM score</strong></td>
<td>2.67 (1.20)</td>
<td>3.05 (1.36)</td>
<td>3.50 (1.20)</td>
</tr>
<tr>
<td><strong>Mean (SD) BPVS score</strong></td>
<td>105.7 (12.6)</td>
<td>103.7 (11.7)</td>
<td>106.2 (9.6)</td>
</tr>
<tr>
<td><strong>Mean (SD) A’ score: self-owned items</strong></td>
<td>0.86 (0.16)</td>
<td>0.90 (0.09)</td>
<td>0.93 (0.04)</td>
</tr>
<tr>
<td><strong>Mean (SD) A’ score: other-owned items</strong></td>
<td>0.83 (0.17)</td>
<td>0.89 (0.07)</td>
<td>0.92 (0.03)</td>
</tr>
<tr>
<td><strong>Mean (SD) Hit rate: self-owned items (%)</strong></td>
<td>79.8 (16.1)</td>
<td>82.3 (10.9)</td>
<td>76.4 (13.1)</td>
</tr>
<tr>
<td><strong>Mean (SD) Hit rate: other-owned items (%)</strong></td>
<td>72.8 (14.1)</td>
<td>78.4 (10.1)</td>
<td>74.2 (8.6)</td>
</tr>
<tr>
<td><strong>Mean (SD) False alarm rate (%)</strong></td>
<td>18.0 (22.3)</td>
<td>13.1 (15.1)</td>
<td>3.6 (3.7)</td>
</tr>
</tbody>
</table>