

Exploring individual differences in self-reference effects for agency and ownership
in 5- to 7-year-olds

Ruth M. Ford^{1*} and Sheila N. Lobao²

1. Ruth M. Ford, Anglia Ruskin University, United Kingdom
2. Sheila N. Lobao, Swansea University, United Kingdom

*Requests for reprints should be addressed to Ruth M. Ford, Department of Psychology,
Anglia Ruskin University, Cambridge, CB1 1PT, United Kingdom.
E-mail: ruth.ford@anglia.ac.uk

Abstract

Evidence that self-relevant information enjoys a privileged status in memory is termed the *self-reference effect* (SRE). Testing 5-to 7-year-olds ($n = 39$), we aimed to shed light on the SRE by examining the memorial advantage for self-relevant information as a function of general ability, theory of mind, empathy, and recollection. Playing in pairs, children were presented with an array of pictures and took turns to select pictures (agency) and turn them over to reveal to whom they belonged (ownership). Later they viewed the studied pictures intermixed with new ones and provided recognition- and source memory judgments. There was a robust SRE in recognition memory, mainly for agency, which varied positively with intellectual ability but negatively with theory of mind, empathy and recollection. These findings accord with claims that self-referential information benefits from elaboration handled by domain-general processes, with the SRE counteracted by social processes that increase attention to other people.

Considerable research has shown a *self-reference effect* (SRE) in memory such that information encoded in relation to the self is remembered better than information with little or no personal relevance. In an early study of this phenomenon, Rogers, Kuiper and Kirker (1977) presented adult participants with a series of adjectives pertaining to personality traits (e.g., “friendly”) and asked them to decide whether each word accurately described their own personality. Compared with a condition which encouraged semantic processing, self-referent encoding led to better recall of the words. Subsequent investigations have shown that people have superior recognition memory for neutral stimuli (e.g., pictures, abstract shapes) that were paired with their own name or image rather than someone else’s during encoding, thus giving them a sense of ownership over those stimuli (Cunningham, Turk, Macdonald, & Macrae, 2008; Cunningham, Brady-Van den Bos, & Turk, 2011; Grisdale, Lind, Eacott, & Williams, 2014; Sui, He, & Humphreys, 2012). Likewise, studies of action memory have revealed a recall advantage for actions that people carried out themselves relative to actions that they observed being carried out by other people (also known as the *self-performed task effect*; Mulligan & Hornstein, 2003; Ross, Anderson, & Campbell, 2011).

The SRE is likely to reflect a confluence of factors (reviews by Cunningham & Turk, 2017; Sui & Humphreys, 2017). First, self-relevant information might receive more elaborate and extensive encoding than other-relevant information, reflecting its importance to the large body of knowledge in long-term memory comprising the self-concept (Rogers et al., 1977; Symons & Johnson, 1997). Second, evidence that self-relevant information is perceptually salient suggests that the self-system continually monitors the environment for such information, which grabs attention automatically (i.e., a self-attention network; Cunningham, 2016). Third, self-relevance could facilitate the integration of event details into a unitary, coherent memory representation, a process known as episodic binding which is assumed to result in enhanced feelings of recollection (Conway & Dewhurst, 1995). Finally, in the case

of self-performed actions, memory retrieval is likely to benefit from detailed records of planning and motoric processes laid down during encoding (Mulligan & Hornstein, 2003). Consistent with the suggestion that self-referential processing is special, neuroimaging evidence links it – but not other-referential processing - with increased activation in the medial prefrontal cortex (Northoff, Heinzl, de Greck, Bermpohl et al., 2006).

While the SRE is well documented in research with adult participants, only a handful of studies have evaluated the effect in children (e.g., Bennet & Sani, 2008; Cunningham, Vergust, Macrae, & Turk, 2013; Cunningham, Brebner, Quinn, & Turk, 2014; Halpin, Puff, Mason, & Marston, 1984; Pullyblank, Bisanz, Scott, & Champion, 1985; Ray, Shelton, Hollon, Michel et al., 2009; Ross et al., 2011; Sui & Zhu, 2005; Turk et al., 2015). Within this small literature, the focus has been on establishing the typical age at which the SRE emerges. Results suggest that the SRE can be observed in recognition memory by 3.5 years of age (Ross et al., 2011) and in source memory by 4 years of age (Cunningham et al., 2014). Although one study with 7- to 10-year-olds indicated a larger SRE in older children, an effect attributed to greater self-knowledge and, hence, more extensive elaboration of self-referential information (Ray et al., 2009), Cunningham et al. (2014) found that the magnitude of the SRE in 4- to 6-year-olds was not predicted by age. Based on these findings they concluded that during early childhood the SRE is more likely to reflect the automatic capture of attention by self-relevant cues.

Likewise, two studies testing 4-6 year olds found no correlation between the size of the SRE and cognitive ability as gauged by verbal ability and theory of mind (Cunningham et al., 2013) or forwards digit span (Cunningham et al., 2014). Nevertheless, Cunningham et al. (2014) speculated that the SRE might start to show positive links with age and cognitive ability as children grow older, reflecting the increasing importance of elaborative encoding as children develop their self-concept. They also raised the possibility that processes responsible

for diminishing egocentricity with age might counteract the SRE by encouraging greater attention to the actions and experiences of other people.

The Present Study

In the present study, we aimed to shed light on the mechanisms either driving or opposing the SRE in young children using a correlation analysis. Specifically, we explored individual differences in the magnitude of the SRE as a function of general intellectual ability, theory of mind, empathy and recollection. On the one hand, we assumed that the SRE would be *augmented* by domain-general processes harnessed for the identification and elaboration of self-relevant details. Children with higher IQs tend to outperform children with lower IQs on tests of event memory, a finding attributed partly to superior information processing skills that support more intricate encoding (Brown & Pipe, 2003; Roebbers & Schneider, 2001). Intelligence is regarded as an adaptive function that helps people to cope effectively with their environment (Weschler, 1944). Given the suggestion that the SRE serves the important ecological function of ensuring that information pertinent to personal wellbeing is remembered (Cunningham, 2016), we reasoned that children with better general ability would also be more likely to prioritize encoding of self-relevant details. Thus, we predicted a *positive* association between the SRE and general intellectual ability.

Conversely, we assumed that the SRE would be *diminished* by social cognitive processes encouraging children's encoding and retrieval of information linked with other people. We therefore predicted a *negative* association between the SRE and both theory of mind and empathy. Likewise, we hypothesized a *negative* relation between the SRE and recollection as gauged by an episodic binding task involving objects and scenes. Baddeley (2007) proposed that episodic binding occurs within the episodic buffer, a limited-capacity and temporary storage system that integrates information from different sources. The episodic buffer is controlled by the central executive, which facilitates recollection and influences the

content of the buffer through selective attention. While binding of objects and scenes appears to be effortful (e.g., Nieznański, 2013), it has been suggested that details pertaining to the *self* tend to cohere relatively easily and automatically (Conway & Dewhurst, 1995). We therefore reasoned that any boost to the SRE from superior binding and recollection of self-referential details would be offset in children who are better able to integrate non self-relevant information through controlled attention.

Participants were 5- to 7 years old, an age by which children have acquired a well-developed store of self-knowledge, as well as the kind of metacognitive self-awareness that enables them to reflect on their own mental processes and those of other people (Rochat, 2003). To elicit the SRE, we devised a picture selection game for which pairs of children were shown an array of pictures on the table and took turns to select a picture and turn it over. The game was competitive, which we intended would give children an incentive to pay attention to what their partner did. Moreover, it was designed to yield independent measures of the SRE for *agency* and *ownership*. Children exercised agency in choosing which pictures to pick up from the table (i.e., self-determined and goal-directed action; Bandura, 1989) while they experienced ownership in terms of a marker on the reverse side of each picture that assigned it to one or the other player. Later, children were assessed for their recognition-memory of the pictures and their ability to recall who selected- versus owned each one.

Based on previous research, we anticipated that participants would remember self-selected pictures better than other-selected pictures and self-owned pictures better than other-owned pictures, thus showing reliable SREs for both agency and ownership (e.g., Ross et al., 2011). Following an earlier study by Cunningham et al. (2011), we also predicted a significant interaction between the two domains. In Cunningham et al.'s investigation, adults were presented with a selection of objects and asked to choose some to keep and some to give to the other player. A subsequent memory test showed that the recognition-memory

advantage for self-owned items was accentuated when they had been self-chosen, while in source-memory judgments the likelihood that participants correctly attributed ownership to themselves was increased for items that were self-chosen. Such findings are likely to reflect a combination of superior episodic binding associated with self-referential information and enhanced attention to such information resulting in greater trace strength (Durbin, Mitchell, & Johnson, 2017).

Method

Participants

The participants were 39 children aged 5- to 7 years ($M = 75.23$; $SD = 6.87$; 10 5-year-olds, 27 6-year-olds and 2 7-year-olds). They comprised 18 girls and 21 boys attending mainstream classes in two state primary schools in a middle SES area. Most were Caucasian, all spoke English as their first language, and all were showing typical development as judged by their teachers. Children's participation in the study was subject to informed written consent from their head teacher and main caregiver. Permission to conduct the study was granted by our university Research Ethics Committee.

Materials and Procedure

Children completed one activity to measure the SRE (Picture Selection Game). Additionally, they were assessed for general intellectual ability, theory of mind, empathy, and recollection. Testing took place individually in a secluded location at the children's school and was conducted by two female researchers who handled different aspects of the data collection. There were three test sessions spread over several weeks. If any child was absent from school on a test day then the researcher returned later to administer the tasks. We succeeded in obtaining a complete data set with the exception of two children who did not undertake the test of memory span.

Picture Selection Game. To evaluate the SRE, children were asked to play a picture selection game in pairs (given our sample size of 39, one child performed the activity with a partner who was not a participant). The two children were seated adjacent at a table and each had a small box placed next to them with their name printed on it and a coloured shape (either a yellow triangle or a red triangle) affixed to it. Displayed face-up on the table was a set of 36 colour photographs of everyday objects and animals arranged in a 6 x 6 matrix (see Figure 1 for examples). Unseen by the children, half the pictures had a yellow triangle on the back and the rest had a red triangle on the back (random positioning). Children were informed that they would take turns to select a picture from the table, label it (e.g., by saying, “This is a cat”), and then turn it over to see whose marker was on the back. They were further told that if the picture had their marker then they should announce, “This is mine” but if it had the marker for the other child then they should announce, “This is yours”. Finally, they were instructed to place the picture in the appropriate child’s box. It was explained that half the pictures on the table had red triangles on the back while the other half had yellow triangles and that the winner of the game would be the first child to get all their pictures placed in their box. The loser of the game was therefore the child who was revealed to own the last picture remaining on the table. To emphasise the competitive nature of the game, the researcher showed two attractive pens to the children and stated that the winner would be allowed to choose their favourite pen as a prize, with the other pen going to the loser. Throughout the game, the researcher encouraged children to pay attention to events even when it wasn’t their turn.

The memory test was conducted around 2 hours later. Each child was shown all the studied pictures one at a time, intermixed with 18 distracter pictures, and asked, “Was this picture one of the pictures you saw in the game, yes or no?” If they answered affirmatively then they were asked, “Who did this picture belong to?” and “Who picked this picture up from the table?” The order of questions was counterbalanced, with 20 children being

questioned about ownership before agency and 19 children being questioned about agency before ownership. It was emphasised to children that if they didn't know the answer to any of the questions then they should respond "don't remember" rather than guess.

The 36 studied pictures in the Picture Selection Game fell into four categories which varied in size between participants given that the researcher had no control over which pictures they chose. The categories comprised (1) self-selected and self-owned pictures ($M = 8.85$, $SD = 1.35$, range = 6-11), (2) self-selected and other-owned pictures ($M = 9.15$, $SD = 1.35$, range = 7-12), (3) other-selected and self-owned pictures ($M = 9.15$, $SD = 1.35$, range = 7-12), and (4) other-selected and other-owned pictures ($M = 8.85$, $SD = 1.35$, range = 6-11). Recognition-memory accuracy was evaluated for each of the four categories by dividing the number of endorsements by the number of experienced items in that category. For example, a child who experienced eight self-selected/self-owned pictures and judged correctly that they saw six of those pictures during the game earned a score of 0.75 for recognition-memory accuracy in that category. For each recognised picture, children were deemed to have made a correct source decision if they succeeded in recalling *both* who selected the picture and who owned it (thus, showing accurate binding of agency and ownership). Source memory was then evaluated for each category of pictures by dividing the number of correct source judgments by the number of items in that category. For example, a child who encountered nine self-selected/self-owned pictures and judged both agency and ownership correctly for six of the pictures earned a score of .67 for source memory for this category.

General Intellectual Ability. General intellectual ability was gauged by tests of verbal ability and memory span. Verbal ability was measured with the British Picture Vocabulary Scale (BPVS 2nd Edition: Dunn, Dunn, Whetton, & Burley, 1997) and memory span was measured with the Digits Forwards subtest of the British Ability Scales (BAS II; Elliott, Smith, & McCulloch, 1996). These tests index crystallized intelligence and fluid

intelligence respectively (e.g., Aeschlimann, Voelke, & Roebbers, 2017) and each was scored to yield a mental age in months.

Theory of Mind. Theory of mind was assessed using two higher-order false belief tests, each comprising a series of questions and scored out of 5 (see Appendix for details). The overall score (out of 10) was converted to proportional accuracy.

Empathy. Children were assessed for empathy using the Index of Empathy for Children and Adolescents, a self-report measure that is suitable for children as young as five years of age (BEI; Bryant, 1982). The BEI consists of 22 statements designed to gauge children's propensity for recognizing and responding sensitively to the feelings of other people. The test was administered using to the 'yes/no' method recommended for younger participants to yield a total score out of 22.

Recollection. Recollection was estimated using a memory test for object/scene bindings. The study phase involved a PowerPoint presentation with 30 slides, each depicting an animal situated in a distinctive and appropriate background (e.g., a camel in a desert, a dog in a garden; see Figure 2 for examples). Materials developed for the test phase comprised three further PowerPoint presentations, each of 60 slides. Each test set comprised 10 previously studied animals on a white background (*old animals*), 10 non-studied animals on a white background (*new animals*), 10 previously studied backgrounds minus animals (*old backgrounds*), 10 non-studied backgrounds minus animals (*new backgrounds*), 10 previously studied animal/background combinations (*old pairings*), and 10 non-studied combinations of previously presented animals and backgrounds (*new pairings*; see Figure 2, third picture). Counterbalancing ensured that each studied animal or background appeared individually in one test set, combined with its original partner in the second set, and combined with a new partner in the third set.

The procedure comprised two phases conducted 24 hours apart. During the study phase, all children viewed the same 30 slides, and during the test phase they viewed 60 slides (with 13 participants assigned to each set). Children were told that they would be shown some pictures before being tested on their memory for the pictures. The researcher explained that each picture would show an animal in a particular place and that they would need to remember both the animal and the place. The slides were presented for around 10 seconds each. For all slides, children were asked to identify the animal and describe the background.

During the test phase, children were informed that they would see another slide show and that for every picture they would have to decide whether they saw it the day before. To emphasise this, the researcher asked children a recognition-memory question as each picture was presented. When individual animals were presented she asked, “Did you see *this animal* in any of the pictures yesterday?” When individual backgrounds were presented she asked, “Did you see *this place* in any of the pictures yesterday?” When animal/background pairs were presented she asked, “Did you see *this animal in this exact place* in any of the pictures yesterday?” For all animal/background pairs the researcher stressed that, even if children remembered the animal and the place individually, they should respond “no” if they didn’t remember the animal and place together. As for the picture selection task, children were permitted to answer, “I don’t remember”.

Scores for recollection were generated using the process dissociation procedure (PDP) devised by Jacoby (1991). That is, the proportion of “yes” responses to new pairings was subtracted from the proportion of “yes” responses to old pairings. Because old pairings and new pairings were all made up of studied elements they were matched in terms of familiarity and could not be distinguished on this basis. Thus, children’s ability to differentiate between the two sets of items – demonstrated by endorsing old pairings and rejecting new pairings - provided an indicator of their recollection.

Results

Preliminary data screening showed that all variables had distributions that were acceptably normal and without extreme outliers (i.e., $|z|$ scores ≤ 3). Consequently, analyses were conducted on the untransformed raw data. Table 1 presents descriptive statistics for the memory variables and the individual differences variables.

Descriptive Statistics

The top section of Table 1 shows results for the Picture Selection Game. In line with previous research (Cunningham et al., 2008, 2014), we corrected the recognition- and source-memory scores by taking account of false alarms. For recognition memory, we subtracted the proportion of false alarms (i.e., incorrect recognition of new pictures) from the proportion of correctly recognized studied pictures. For source memory, we corrected the results separately for the four categories of pictures. For example, we corrected scores for the self-selected/self-owned category by subtracting the proportion of “self-selected/self-owned” attributions to false alarms from the proportion of correct “self-selected/self-owned” attributions to the relevant studied pictures. In fact, the corrected scores differed little from the raw scores given a very low rate of false alarms (only 8 children wrongly claimed to recognise any novel pictures; of these, 7 children made a single false alarm and one child made two false alarms).

Proportional recognition-memory accuracy for each category of pictures was superior to the level of .50 expected by chance, p values $< .05$. Likewise, proportional source-memory accuracy for each category of pictures was reliably superior to the level of .25 expected by chance, p values $< .05$. Children occasionally answered “don’t know” to the source memory questions with 16 of 39 participants using this response at least once ($M = 1.38$, $SD = 2.70$, range = 0 to 11). Independent-samples t tests that compared source memory for each picture type between children who were asked about agency first ($n = 19$) and children who were

asked about ownership first ($n = 20$) showed that none of the group differences was significant (p values ranging from .179 to .828).

The bottom section of Table 1 shows results for the individual differences variables. Means for verbal ability and memory span were commensurate with chronological age while both measures of social cognition (theory of mind, empathy) had a wide range of scores with no floor or ceiling effects. In the PDP, used to estimate recollection, there was a high rate of endorsement of studied pictures (animals $M = 8.61$ $SD = 1.21$; places $M = 8.56$ $SD = 1.43$; pairs $M = 9.69$; $SD = 0.61$) and a low rate of endorsement of novel pictures (animals $M = 0.26$ $SD = 0.50$; places $M = 0.56$ $SD = 0.82$; pairs $M = 3.92$; $SD = 2.31$). A one-way repeated-measures ANOVA on recognition-memory accuracy in each category (i.e., endorsements of studied pictures minus endorsements of novel pictures) revealed a significant effect of picture type, $F(2, 76) = 28.64$, $p < .001$, $\eta_p^2 = .43$. Within-subjects contrasts showed no reliable difference in recognition-memory accuracy for animals versus places, $F(1, 38) = 1.42$, $p = .242$, $\eta_p^2 = .04$. However, accuracy for the animal/place pairings was significantly lower than accuracy for the individual items overall, $F(1, 38) = 42.11$, $p < .001$, $\eta_p^2 = .53$, as expected if correct responses required recollection.

Chronological age was correlated with verbal ability, $r(39) = .59$; $p < .001$, but with no other individual differences variables, p values $> .05$. Additionally there were significant associations were between verbal ability and memory span, $r(37) = .56$; $p < .001$, and between memory span and theory of mind, $r(37) = .35$; $p < .05$. Given the existence of a reliable correlation between verbal ability and memory span, we converted these variables to z scores and averaged them to create a composite score for general ability.

The Self-Reference Effect

For recognition memory, a 2 x 2 repeated-measures ANOVA for agency (self-selected versus other-selected) and ownership (self-owned versus other-owned) revealed a significant

effect for agency (.91 vs. .74), $F(1, 38) = 58.67, p < .001, \eta_p^2 = .61$, no effect of ownership (.85 vs. .80), $F(1, 38) = 3.48, p = .070, \eta_p^2 = .08$, and a significant interaction, $F(1, 38) = 6.47, p = .015, \eta_p^2 = .15$. Follow-up tests indicated that self-owned pictures were endorsed more frequently than other-owned pictures only when other-selected, $p < .05$.

For source memory, a 2 x 2 repeated-measures ANOVA for agency (self-selected versus other-selected) and ownership (self-owned versus other-owned) revealed a significant effect of agency (.49 vs. .41), $F(1, 38) = 4.89, p = .033, \eta_p^2 = .11$, no effect of ownership (.42 vs. .48), $F(1, 38) = 2.98, p = .093, \eta_p^2 = .07$, and a significant interaction, $F(1, 38) = 6.72, p = .013, \eta_p^2 = .15$. Follow-up tests showed that the accuracy of source judgments regarding other-selected/self-owned pictures was lower than for other picture categories, p values $< .05$.

Predicting Individual Differences in the SRE

To identify predictors of individual differences in the SRE, we focused on the three effects that had been found significant above, that is, (1) the effect of agency in recognition memory, (2) the effect of ownership for other-selected pictures in recognition memory, and (3) the effect of agency in source memory. For each effect we generated an SRE score by subtracting children's memory accuracy for other-referential information from that for self-referential information. For example, the SRE for agency in recognition memory was equal to: recognition-memory accuracy for self-selected pictures *minus* recognition-memory accuracy for other-selected pictures.

Given our assumption that some individual differences variables would correlate positively with the SRE (i.e., general ability) while others would correlate negatively with the SRE (i.e., theory of mind, empathy, recollection), we controlled for positive associations between the variables by calculating their *partial* correlations with the SRE. Findings are presented in Table 2. To provide clarity on any null outcomes, Table 2 also shows the partial correlations between the individual differences variables and the memory measures from

which the SREs were derived. Confirming predictions, the SRE for agency in recognition memory showed a positive partial correlation with general ability but negative partial correlations with theory of mind, empathy, and recollection, p values $< .05$. In the case of the SRE for ownership for other-selected pictures in recognition memory, there were no significant results. In the case of the SRE for agency in source memory, there was a negative partial correlation with empathy, $p < .05$.

Chronological age failed to predict outcomes for any of the memory measures or SREs, all p values $> .05$, and the pattern of findings described above was unchanged when age was included in the partial correlations. Likewise, when we repeated the analyses using results for either verbal ability or memory span entered individually in place of general ability, the same trends emerged. Thus, the SRE for agency in recognition memory showed a unique, positive correlation with verbal ability (partial $r = .39$, $p = .017$) and a unique, positive correlation with memory span (partial $r = .42$, $p = .013$).

Discussion

Our aim in the present study was to examine the relations between various individual differences variables (general intellectual ability, theory of mind, empathy and recollection) and the magnitude of the SRE in young children. In the ensuing discussion, we use this correlational evidence to offer suggestions regarding the causal mechanisms of the effect. In pairs, participants played a competitive picture selection game designed to measure SREs for agency (i.e., who selected each picture) and ownership (i.e., who received each picture). We assumed that domain-general measures of intellectual ability would index processes involved in the preferential encoding and elaboration of *self*-referential information and, thus, would show a *positive* relation with the size of the SRE. In contrast, we anticipated that measures of social understanding would index processes supporting the identification and elaboration of *other*-referential information and, thus, would show *negative* relations with the size of the

SRE. Likewise, we assumed that better recollection would counteract the SRE by helping children to remember the less salient agency/ownership links pertaining to the other child. We first discuss our findings in relation to the SRE, and then go on to consider the key findings of the present study, namely, the correlates of the SRE.

Results showed that we were successful in eliciting a significant SRE for agency in *both* recognition- and source memory. In contrast, the SRE for ownership was evident only for other-selected pictures in recognition memory and lacking altogether in source memory. Thus, the expected interaction between agency and ownership appeared only in recognition memory; specifically, while self-selected/self-owned pictures were not recognized better than self-selected/other-owned pictures, accuracy was higher than for other-selected/self-owned pictures while the worst results were recorded for the other-selected/other-owned category. In source memory, however, judgements regarding other-selected/other-owned pictures were no less accurate than for self-selected/self-owned pictures. It seems unlikely that children's impressive source memory for other-selected/other-owned items meant that they assigned pictures to this category by default whenever they failed to recall source information. Not only did we offer children the option of answering "don't remember", the positive association between empathy and source-memory accuracy for other-selected pictures reinforces the conclusion that source attributions to this category were not predominantly guesswork.

Our failure to find a robust SRE for ownership in either recognition- or source memory contradicts some previous studies that reported *greater* SREs for ownership than agency, at least in recognition tests (e.g., Cunningham et al., 2008). We speculate that failure to yield a clear memory advantage for self-owned items in the present case reflects the strong incentive for children to pay attention to which pictures their opponent picked up from the table, because of the implications for who would win the game. In contrast, the strong SRE for agency in our study can be attributed to the fact that children were free to choose which

picture to move on each of their turns, unlike the adult participants in Cunningham et al.'s study who merely had to follow the guidance of the researcher in selecting which pictures to act upon. Our findings for the agency SRE replicate numerous studies of the subject-performed task effect in children (e.g., Ross et al., 2011), an effect that could be attributed to the additional information typically encoded in relation to self-performed actions such as motoric processes and planning. Additionally, it is possible that our strategy of allowing children to choose which pictures to act upon might have given them a sense of ownership over those pictures regardless of formal assignment.

With regard to our main aim, which was to explore the correlates of the SRE, our predictions were confirmed in the recognition-memory test when considering the SRE for agency (i.e., the memorial advantage for self-selected pictures over other-selected pictures). Partial correlations, controlling for the influence of all remaining individual differences variables, showed that the magnitude of the SRE increased with better verbal ability and memory span but decreased with better theory of mind, empathy and recollection. These findings are consistent with the suggestion that the SRE is a complex phenomenon reflecting a competition between factors favouring memory for one's own experiences and those favouring memory for others' experiences (Cunningham et al., 2014; Gillespie-Smith, Ballantyne, Branigan, Turk, & Cunningham, 2018). Indeed, the activity used to elicit the SRE in our study might have been especially suited to demonstrating these opponent processes. First, the fact that children actively selected which information became self-referential (i.e., by deciding which pictures to pick up) could have enhanced the chances that they encoded and elaborated the information in relation to self-knowledge. Children may have been inclined to choose pictures that had some personal significance, for example, pictures that evoked memories from their own experience and thus were familiar and/or attractive. Second, the competitive nature of the activity likely served to heighten children's interest in their

partner's choices and emotional reactions. The greater the attention paid to the other child's actions and experiences, the more thoroughly children would have encoded such details into their memory for the activity.

In terms of social understanding, it is possible that the empathy test gauged the degree to which children considered their opponent's affective reactions during the game (i.e., displays of excitement or disappointment as ownership of each picture was revealed) while the theory-of-mind tests instead tapped their speculation regarding their opponent's intentions and motivations (such as the reasons why they selected a particular picture). While we did not record formal observations of children's behaviour, the researcher noted that most were fully engaged in the activity, spent time deliberating about which pictures to choose, and produced obvious displays of emotion as the ownership of each picture was revealed. In terms of recollection, superior ability to bind objects and scenes was linked negatively with the SRE. Baddeley (2007) argued that the binding processes supporting recollection can be either automatic or effortful, with automaticity promoted by greater perceptual or conceptual similarity between event features. While object/scene binding appears to be resource demanding (e.g., Nieznański, 2013), it has been proposed that binding of self-referential details occurs easily (Conway & Dewhurst, 1995). The object/scene task might thus have indexed the efficiency of effortful binding processes that, while contributing to integration of agency and ownership for self-selected pictures, played a more important role in forging cohesive memories of episodes in which pictures were chosen by the other child. On the other hand, given that recollection showed significant, positive associations with recognition-memory for *both* self-selected and other-selected pictures, we cannot rule out the possibility of a ceiling effect such that children with superior powers of recollection had less scope to demonstrate the SRE.

Because the partial correlations reported above were diminished when considering the SRE for agency in source memory, which was predicted only by empathy, it may be the case that recognition probes and source probes initiated different kinds of retrieval processes. In recognition-memory tests, re-presentation of studied items is thought to cue the automatic retrieval of the relevant memory traces with a subjective experience of either familiarity and recollection depending on trace strength (Yonelinas, 2001). The SRE in recognition memory has thus been argued to reflect a greater strength of associations involving self-referential items than other-referential items, including but not limited to item-self associations, due to enhanced attention to the former during study (Durbin et al., 2017). In contrast, the source monitoring framework (SMF: Johnson, Hashtroudi & Lindsay, 1993), proposes that source attributions are controlled and strategically driven. Specifically, the SMF holds that source judgements draw on inferential processes that evaluate memories for their perceptual, semantic and affective content plus records of cognitive operations carried out during encoding, including remembering, imagining, and planning. It is worth noting that our finding of a diminished influence of recollection in source attributions compared to recognition-memory judgements is consistent with the results of developmental investigations of event-related potentials in memory retrieval – which suggest that children struggle with controlled retrieval processes. For example, Sprondel, Kipp and Mecklinger (2011) found that while children showed strong influences of recollection in recognition memory compared to adolescents and adults, there were marked age-related improvements in the contribution of recollection to source memory.

In conclusion, we have presented novel evidence that the magnitude of the SRE in young children is linked positively with general intellectual ability but negatively with theory of mind, empathy and recollection. Of course, we acknowledge that these correlational data cannot prove the direction of causality and that longitudinal studies are needed to examine the

extent to which individual differences variables at younger ages predict the SRE at older ages, controlling for initial SRE, and vice versa (e.g., as for studies exploring the developmental relations between language and theory of mind; Astington & Jenkins, 1999). Our findings also suggest several other avenues for future research. First, exploring the predictors of the SRE for ownership in new studies designed to produce a bigger effect size would reveal whether our failure to uncover significant predictors in the present case reflects the weak SRE or, alternatively, indicates that memory for ownership depends on variables that we neglected to measure. Second, by evaluating the SRE in recognition-memory tests following study conditions of either full or divided attention it might be possible to separate the influences of automatic versus effortful episodic bindings on the effect. Finally, although we tested typically developing children, our results are relevant to evaluations of the SRE in various clinical groups, such as children with autism spectrum disorder (ASD). There has been considerable interest in the potential of SRE paradigms to test claims regarding an impoverished self-concept in ASD (review by Lind, 2010) but evidence of opposing processes regulating the SRE suggests that straightforward comparisons might not be very informative. As indicated by the recent findings of Gillespie-Smith et al. (2018), for example, while ASD children could lack a well-developed self-concept that curbs their elaboration of self-referential information this might not manifest as a diminished SRE if, compared to typically developing children, they show less interest in other people.

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Appendix

Higher-order false-belief stories

Both stories were supported by pictures that were shown to children while the story was narrated.

Story 1: (1) This is Hannah and this is her mother. Mum knows that Hannah wants a puppy for her birthday. Now, today is Hannah's birthday. (2) Mum bought a puppy secretly for Hannah. She didn't tell Hannah because she wanted to surprise her. So, Mum hid the puppy in the garden shed. Hannah said to Mum, 'I really wish I could have a puppy for my birthday present.' But because her Mum wanted it to be a surprise, she said "Sorry Hannah, I couldn't get you a puppy. But instead, I got you a really great toy." (3) Now, while Mum was baking a birthday cake, Hannah went outside to play. She went to the shed in the garden to fetch her skipping rope. When she opened the door, Hannah was very surprised! She found the cute puppy with a birthday ribbon!! "Wow" she thought, "Mum really got me a puppy after all!" So, Hannah found the puppy in the shed, didn't she? But Mum didn't see that Hannah found the puppy. (4) While Hannah was outside, her grandmother phoned Mum. Grandma said to Mum, "I rang up to say Happy Birthday to Hannah." Then, Grandma asked Mum, "What does Hannah think you got her for her present?"

Second-order false belief question: What will Mum say to Grandma?

Answer: Toy = 1; Puppy = 0

Justification question: Why will Mom say that?

Answer: Because she didn't know Hannah found the puppy = 2; Because she told Hannah she got her a toy and not a puppy = 1; Any other answer = 0

Memory control question 1: Where did Mum hide the puppy?

Answer: Shed = 1; Any other answer = 0

Memory control question 2: Does Mum know that Hannah found the puppy in the shed?

Answer: No = 1; Yes = 0

Story 2: (1) John and Mary are brother and sister. One day, they visit the park to play. While they are there, an ice-cream van pulls up. John and Mary want to buy an ice-cream each but they don't have any money. So, Mary says to John that she will run home and get some money. (2) While Mary is gone, the ice-cream van leaves the park and drives around the corner to stop near the church. John watches it move to the church. (3) Mary gets the money from home and starts running back to the park. However, in the distance she catches sight of the ice-cream van next to the church. "Oh" says Mary to herself, "The ice-cream van has moved! I'd better go to the church" (4) Meanwhile, John is waiting for Mary at the park wondering why she is taking so long.

Second-order false belief question: Where does John think that Mary will look for the ice-cream van?

Answer: Park = 1; Church = 0

Justification question: Why does he think that?

Answer: Because he doesn't know Mary saw the van move = 2; Because the van was at the park first = 1; Any other answer = 0

Memory control question 1: Where was the ice-cream van at the start of the story?

Answer: Park = 1; Church = 0

Memory control question 2: Does John know that Mary saw the ice-cream van near the church?

Answer: No = 1; Yes = 0

Table 1. Descriptive statistics for all variables

	<i>Range</i>	<i>Mean</i>	<i>SD</i>
<i>Picture Selection Game: Recognition Memory</i>			
Self-Selected/Self-Owned	.71-1.00	.91	.08
Self-Selected/Other-Owned	.63-1.00	.91	.09
Other-Selected/Self-Owned	.43-1.00	.78	.14
Other-Selected/Other-Owned	.30-1.00	.69	.21
<i>Picture Selection Game: Source Memory</i>			
Self-Selected/Self-Owned	.10-1.00	.50	.23
Self-Selected/Other-Owned	.13-.88	.47	.23
Other-Selected/Self-Owned	.00-.75	.34	.18
Other-Selected/Other-Owned	.13-.88	.48	.22
<i>Individual Differences Variables</i>			
BPVS age	44-103	72.59	15.34
Digits Forward age	55-98	76.65	11.64
Theory of Mind	.3-1.00	.63	.17
Empathy	10-21	15.97	2.89
Recollection	.2-1.00	.58	.23

Note. BPVS age and Digits Forward age = age equivalent scores in months; empathy = BES scores (maximum possible score = 22). All other variables = proportional accuracy.

Table 2. Partial correlations between (1) the individual differences variables, and (2) measures of memory and the SRE, controlling for all remaining individual differences variables

	General Ability	Theory of Mind	Empathy	Recollection
<i>Recognition Memory</i>				
Self-Selected	.31	-.16	.13	.39*
Other-Selected	-.37*	.36*	.40*	.49**
SRE Agency	.47**	-.42*	-.35*	-.36*
<i>Recognition Memory</i>				
Other-Selected/Self-Owned	-.23	.17	.31	.27
Other-Selected/Other-Owned	-.34*	.37*	.33*	.49**
SRE Ownership	.17	-.24	-.10	-.30
<i>Source Memory</i>				
Self-Selected	-.21	.17	-.35*	.37*
Other-Selected	-.14	.31	.42*	.31
SRE Agency	-.06	-.11	-.54**	.06

* $p < .05$, ** $p < .01$

List of Figures

Figure 1. Examples of pictures presented in the Picture Selection Game

Figure 2. Examples of studied (first two pictures) and novel (third picture) animal/place pairs in the object/scene binding task

Figure 1.



Figure 2.

