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"That one makes things small": Experimentally induced spontaneous memories in 3.5-year-olds

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Abstract

We introduce a new method for examining spontaneous (unprompted) autobiographical memories in 3.5-year-old children, by inducing them in a laboratory setting. Thirty-eight 3.5-year-olds, who had previously participated in a study in our lab involving highly unique props, were brought back after a one-month delay to the same lab arranged as in the original study and with the same Experimenter present. While waiting for the Experimenter in front of the props, their spontaneous verbalizations about the previous unique experiment were recorded, scored, and compared to those of 29 naïve Controls of the same age. The children in the experimental group produced significantly more spontaneous verbalizations related to the to-be-remembered event measured on a variety of dimensions. The study introduces a promising new approach to investigating spontaneous memories in young children in a controlled lab setting. The findings are discussed in relation to involuntary autobiographical memories as examined in adults.

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1.0 Introduction

Many parents have experienced incidents in which their young children spontaneously have recalled memories where the memory apparently just came to the child's mind without any deliberate attempt to recall. The following excerpt from Nelson and Ross' (1980) diary study serves as an illustrative example:

> […] a toddler who had moved away from his old neighborhood before being able to say the name of a friend who had lived down the block, clearly yelled the friend's name "Ar-wen-da, Ar-wen-da" (Arlen there) when she passed the house one and a half months later. (p. 96)

In the adult memory literature past events that come to mind with no preceding attempts at retrieval are called *involuntary autobiographical memories* (Berntsen, 1996). Recently there has been an upsurge of studies on involuntary memories in adults (Berntsen, 2009, for a review). It has been claimed that involuntary memories constitute a basic mode of remembering that is universal and at least as frequent in daily life as voluntary autobiographical memories – that is, memories retrieved through a deliberate and goal directed retrieval strategy (Berntsen, 2010, 2012). Involuntary autobiographical memories appear to require less executive control and to be highly dependent on associative mechanisms. As a consequence it has been proposed that such memories are less cognitively demanding and therefore presumably present earlier in life than memories retrieved in a strategic and goal-directed fashion (Berntsen, 2012; see also Todd & Perlmutter, 1980).

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However, systematic research on the issue from a developmental perspective is virtually non-existent, and as a consequence surprisingly little is known about involuntary autobiographical memories in early childhood[1]. The absence of systematic research on the topic from a developmental perspective may, at least in part, be due to methodological obstacles when attempting to study involuntary memories in children. When examining involuntary memories in adults, participants are typically asked to record such memories when they come to mind for example by using a structured diary or an electronic recording device. In order to accomplish this task, they are being carefully instructed and provided with illustrative examples of involuntary memories (e.g., Berntsen, 1996, 2009). However, when considering preschool children, such instructions would not work, because young children do not possess the meta-cognitive abilities required to understand them and to monitor the recording of the memories.

In order to circumvent this methodological problem, in the present study we have chosen to employ a term that does not imply advanced meta-cognitive abilities on the children's side. Thus, we are interested in children's *spontaneous memories*, which we define as *verbally produced, environmentally cued,* and *unprompted memories.* Spontaneous memories as defined here, therefore (a) will have to be *verbally* produced in order to avoid speculations concerning whether the memories are explicit or not; (b) will have to be *environmentally cued* as is typically the case in adult examples of involuntary memories (Berntsen, 2009); and importantly (c) will have to be *unprompted*, that is, not occur as a result of prompts of any kind as for instance, explicit or implicit questions directed at the child, or direct or indirect demand characteristics exerted on the child. Whether spontaneous memories as defined here qualify as involuntary memories in the 'adult' sense or not cannot be assessed with certainty. We return to this possibility in the discussion.

[1] It should be noted that some studies (Dufresne & Kobasigawa, 1989; Jones, Swift, & Johnson, 1988; Newman, 1990; Poddubnaya, 1981; Smirnov & Shlychkova, 1977; Sophian & Hagen, 1978) have used the term involuntary (or non-deliberate) memories to refer to involuntary (or non-deliberate) *encoding* of a memory, and not involuntary *recall* as the term is used in the present context.

As will be made clear in the following literature review on 'spontaneous' memories in young children, no one has hitherto examined young children's spontaneous (unprompted) memories by controlled means. In the present study we attempt to provide the first step in order to remedy this gap in the research literature by introducing a new method for investigating spontaneous memories in young children in a controlled laboratory setting.

1.1 Naturalistic Studies of Everyday Memory in Young Children

A number of studies (Ashmead & Perlmutter, 1980; Hudson, 1990; Nelson, 1989; Nelson & Ross, 1980; Reese, 1999; Todd & Perlmutter, 1980) have used unstructured or semi-structured methodologies, usually diary studies, to examine the characteristics of memory and remembering early in life when observed in naturalistic settings. Although such studies were not designed to capture spontaneous memories exclusively they have often identified spontaneous memory reports as an important category of memory records.

For instance, Nelson and Ross (1980) conducted a structured diary study with 19 children (six 21-month-olds, six 24-month-olds, and seven 27-month-olds) over a three-month period based on carefully written instructions to the mothers to report their child's memories, defined as both recognition and recall of a variety of material. As has been the case with research on adult involuntary memories (e.g., see Berntsen, 2009, for a review) they found that the great majority of spontaneous memory reports appeared to have been triggered by cues in the environment and that external, physical cues were especially dominant (Nelson & Ross, 1980).

Another specific example of a spontaneous memory comes from the diary study by Todd and Perlmutter (1980, p. 82), who referred to a two-year-old who, while looking at a picture of Santa Claus, suddenly referred verbally to an episode that (according to his parents) took place nine months earlier when he had put Sesame Street ornaments on the Christmas tree.

Likewise, as part of a prospective study Reese (1999) asked 58 mothers to record their children's spontaneous talk about their past, when the children were 25 and 32 months old, respectively. The reports were classified according to whether they were simple associations, events, or language based (verbal statements that had been part of events). The cues were classified according to whether they were physical (belonged to the external environment), verbal, or internal. Reese found that the frequency of memory reports referring to events increased from 25 to 32 months, and that physical cues were considerably more frequent than other cues across both times. She also found that the memories were typically about mundane positive events (Reese, 1999). Such dominance of mundane and positive events triggered by external cues is consistent with what has been found in diary studies of involuntary autobiographical memories in adults, although here the dominance of external cues is less pronounced (Berntsen, 2009). Some of the key findings from these studies show that children do indeed have spontaneous memories as defined here, that is, verbally produced, environmentally cued, and unprompted. Note further, that these findings correspond quite well with findings on involuntary memories in adults studied through a structured diary methodology. Such similarities support the idea that the former actually may reflect a precursor for adult involuntary episodic remembering.

Diary studies like the ones cited above excel in having high ecological validity (Todd & Perlmutter, 1980), and they provide evidence that spontaneous memories are present in the lives of many children. However, diary studies have their own weaknesses (e.g., Nelson & Ross, 1980). In most cases diary studies imply potential problems with accuracy and errors in reporting. Furthermore, their validity relies on the parents' ability and willingness to comply with the instructions provided by the researchers (Nelson & Ross, 1980). Finally, children live different lives and therefore remember different episodes, which make the incidents of memory captured in

unstructured settings difficult to compare across children, thus reducing the generalizability of the obtained results.

Some studies have investigated children's verbal memories for significant real-world events, like hurricanes (e.g. Fivush & Hammond, 1989) or trips to emergency rooms (Peterson & Rideout, 1998) while controlling for the aforementioned problems with accuracy, parent compliance, and differences in the to-be-remembered material. Although interesting by themselves, interview studies on real-world events do not provide information about the children's spontaneous memories, since children are explicitly asked about their memories and thus encouraged to strategically retrieve the memories. One exception from this critique is the study by MacDonald and Hayne (1996) where 3- and 4-year-olds participated in a "surprise" visit to a local farm including pony riding. In the week following the visit, the children's parents were instructed not to enquire about the visit but to report any reference to this specific experience provided by the children. The results revealed that the children did indeed spontaneously talk about the farm visit (MacDonald & Hayne, 1996). Compared to other diary studies, the study by MacDonald and Hayne (1996) had better control of the to-be-remembered experience: The researchers knew the exact content of the to-be-remembered event; they knew when the event took place, and the event was the same across children. However, the study shares the limitation present in most diary studies that the data relied on parent reports.

1.2 Laboratory Studies of Event Memory in Young Children

Many studies have investigated children's verbal recall of different kinds of staged events in a lab setting (e.g. Jack, Simcock, & Hayne, 2012; Jones & Pipe, 2002; Kingo, Staugaard, & Krøjgaard, 2014; Morris & Baker-Ward, 2007; Priestley, Roberts, & Pipe, 1999; Simcock & Hayne, 2002, 2003). These lab-based studies resolve some of the aforementioned problems typically present in diary studies. However, just like the interview-based studies cited above, these

experimental studies also share the characteristic that all the children's verbal memories were elicited by direct questions asked by experimenters. Consequently, the verbal productions from the children in these studies cannot be classified as spontaneous memories as defined here since the children were explicitly prompted and therefore most likely in retrieval mode (Tulving, 1983).

A few studies have collected children's 'spontaneous' verbal references to their previous visits to a lab, while the children were tested for their non-verbal memories (Bauer, Kroupna, Schwade, Dropik, & Wewerka, 1998; Bauer, van Abbema, Wiebe, Cary, Phill, & Burch, 2004; Bauer, Wenner, & Kroupina, 2002; Bauer & Wewerka, 1995; Myers, Clifton & Clarkson, 1987). In a study by Meyers and colleagues (1987), five children who had visited the lab between 15 and 19 times in the first 40 weeks of their lives, returned to the lab two years after their last visit. Relative to controls these children retained memory for some of the action sequences they had been exposed to during their previous visits two years earlier. One boy in particular 'spontaneously' produced verbal statements suggesting that he might have been unintentionally reminded of the previous occasion. Nonetheless, given that these statements were made in the context of an experiment where the child was explicitly asked to remember, these memories were not spontaneous as defined here, since they were prompted by means of the overarching memory task.

Studies by Bauer and colleagues (Bauer et al., 1998; Bauer et al., 2004; Bauer et al., 2002; Bauer & Wewerka, 1995) used elicited imitation across long retention intervals, but with two delayed tests including an added verbal memory test. In the present context, the most relevant results from these studies were that children 'spontaneously' reported mnemonic material from the previous lab visits during the first delayed test (Bauer et al., 1998; Bauer et al., 2004; Bauer et al., 2002; Bauer & Wewerka, 1995). Although the verbal reports from the first delayed test were not a result of direct memory requests, they would not qualify as spontaneous memories as defined here, because the setting clearly involved some encouragements to remember the earlier task as the

children were explicitly asked to recall the motor actions of the events (i.e., "You can make a windmill with this stuff. Show me how to make a windmill.").

1.3 Summary

Previous research related to 'spontaneous' memories in early childhood falls into two broad groups: diary studies and lab-based studies. The diary studies provide evidence that young children do at times produce spontaneous memories during everyday life. However, given the fact that none of the studies were explicitly designed to capture the phenomenon of spontaneous memories, and given the inherent lack of control in this methodology, the results obtained in these studies are difficult to compare and generalize.

The lab-based studies, on the other hand, typically have managed to control for the parameters that diary studies leave uncontrolled, that is, accuracy, parent compliance, and equivalence of the to-be-remembered material. In some lab-based studies, 'spontaneous' memory reports have been recorded while the young children attempted to re-enact the to-be-remembered target actions. However, the 'spontaneous' verbalizations recorded in these studies were all produced at a time when the children were explicitly asked to remember an action sequence or equivalent. Consequently, the memories cannot be characterized as unprompted, and the children probably were in retrieval mode (Tulving, 1983). Thus, to the best of our knowledge, there are no lab-based studies that have been designed to investigate spontaneous memories as defined here, and, in effect, no lab-based studies have obtained evidence of unprompted spontaneous memories in young children.

Here, we attempted to induce spontaneous memories of past events in young children in a controlled lab-setting. The design for the study was inspired by recent developments in the study of adult involuntary remembering (Berntsen, Staugaard, & Sørensen, 2013), showing that involuntary

episodic memories often arise as a result of a distinct cue-item match, consistent with the notion of cue-overload (Watkins & Watkins, 1975). The principle of cue overload states that "The probability of recalling an item declines with the number of items subsumed by its functional retrieval cue" (p. 442). In other words, the likelihood of a cue providing access to a given target memory depends on the extent to which this cue is uniquely associated with the target. Its strength declines to the extent it is associated with other memories as well. Applied to the present context this means that if a highly *distinctive* feature from a unique past event is reinstated in the current context, then this optimizes the likelihood that this past event will be brought to mind (Berntsen, Staugaard, & Sørensen, 2013). This principle is of course not limited to involuntary remembering. It is also consistent with the general idea that a careful match of distinct cues between the original to-be-remembered event and the context for retrieval facilitates recall (Hayne, 2004; Newcombe, Lloyd, & Ratliff, 2007).

In the present study, the distinctive feature match was effectively provided by bringing back children to the exact same lab setting, with the exact same Experimenter, where they had previously participated in two controlled memory experiments run in parallel involving highly unique props. By carefully avoiding any kind of prompting, we investigated whether the children's spontaneous talk while waiting for the Experimenter to return from a (fake) phone call would relate to their previous experience in the lab, comparing their responses with those of a control group of children with no previous experience of this kind.

In addition to the primary investigation regarding the attempt to induce spontaneous memories, we also applied two control measures. First, we tested whether these children would spontaneously talk about and provide evidence of memory for the action sequences they had been taught on their previous visits to the lab while being allowed to play with the props. Second, we tested the children's semantic knowledge based on their voluntary replies to explicit questions

regarding the hidden functions of the previously experienced unique props (see below). The explicit questions regarding the hidden functions of the unique props would obviously not inform us about spontaneous memories, and were included *after* the attempt to induce spontaneous memories in order to obtain a control measure of whether the children in the experimental group actually had any recollection of the to-be-remembered material.

Based on previous observations from diary studies, as well as recent evidence with adults from an experimental setting (Berntsen et al., 2013), we hypothesized that the children who had previously experienced the highly unique events in the laboratory would be more inclined to spontaneously produce verbalizations related to the events compared to naïve controls. Regarding the control measures we expected the children in the experimental group to (spontaneously) show better memory (verbally as well as motorically) for the actions related to the unique props than the control group. And finally, we expected the children in the experimental group to demonstrate better semantic knowledge with regard to the explicit control questions on the hidden functions of the unique props.

2.0 Method

2.1 Participants

A total of 67 (35 female, 32 male) 3.5-year-olds (M_{age} = 45.94 months, *SD* = 0.26, range: 45.50-46.70 months) participated in the study. Of these 38 (18 female, 20 male) were in the Experimental Group (M_{age} = 45.92 months, *SD* = 0.29, range: 45.50-46.70 months), whereas the remaining 29 (17 female, 12 male) constituted the Control Group (M_{age} = 45.97 months, *SD* = 0.23, range: 45.60-46.40 months).

The children in the Experimental Group were a sub-sample of children who had previously participated in two different studies run at the same time: a replication study (Dahl, Kingo, &

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Krøjgaard, 2014) of the so-called "Magic Shrinking Machine" (Simcock & Hayne, 2002), and an eye tracking study with movie clips (Kingo & Krøjgaard, 2014). Both studies were conducted in exactly the same lab and by the same female experimenter. The children in the Experimental Group had all visited the lab three times prior to the present experiment: On two consecutive days when they were approx. 39 months of age, and a third time six months later, when they were approx. 45 months of age. Thus, the present test took place one month after the children in the Experimental Group had their most recent visit. The age-matched children in the Control Group had never visited the lab before. The records of the children from both groups had been extracted from a large birth register, and they were recruited by means of contact letters and follow-up phone calls to their parents. All the children were full-term and healthy. Besides receiving a small gift, they were not compensated for their participation.

2.2 Apparatus

The experiment took place in a 30 m^2 lab room arranged in the same manner as when the children in the Experimental Group visited the lab earlier. Of relevance for the present study, the lab consisted of a large table, two custom-made "machines" ("The Magic Shrinking Machine" [hereafter, MSM], 80 cm x 43 cm x 60 cm [L x W x H]; and "The Crazy Duplicator" [hereafter, CDC], 60 cm x 43 cm x 80 cm [L x W x H], see Fig. 1), and an eye tracking booth with a 30" soffit mounted monitor.

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Figure 1

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2.2.1 The two to-be-remembered events.

In the following we briefly outline the two experiments that served as the target events to be remembered in the present study.

The MSM was an exact replica of the device developed and used by Simcock and Hayne (2002, 2003).[2] The CDC was a "foil" machine used as a control device in the replication study. The MSM could, if operated correctly, "shrink" objects, whereas the CDC could, if operated correctly, "copy" objects. In the replication study half of the children were taught how the MSM worked on the first two visits and the other half of the children were taught how the CDC was operated on the first two visits. Then on the third visit, six months later, all the children were asked first to *tell* and subsequently to *demonstrate* by motor means how *both* machines worked. The reasoning was that if the children were able to tell and demonstrate significantly more information about the operations of the machine they had been taught how to operate previously compared to the machine with which they were not familiar, this would be due to memory derived from the first two visits and not due to online reasoning.

In order to make each machine work, the children had to produce five distinct target actions in the correct order. The actions of the MSM were identical to those used in the original experiment by Simcock and Hayne (2002), whereas the five actions for the CDC were constructed to be as different as possible relative to the actions of the MSM in order to minimize carry-over effects between the two devices. The target actions for each machine are specified in Appendix A.

Six different objects for each machine (see Appendix B) were either "shrunk" or "copied". One of the six objects used for each machine was placed on top of each machine and was therefore

[2] We are grateful to Gabrielle Simcock and Harlene Hayne for giving us access to detailed information about the Magic Shrinking Machine.

visible when the children returned to the lab. The remaining five objects for each machine were enclosed in a bag (next to the MSM) or in a basket (next to the CDC).

The other to-be-remembered study was a visual paired comparison task of two film sequences. On the second of the three visits (no movie clips were shown on the first visit) half of the children were familiarized with a 30-second animated movie clip with a crab, whereas the other half of the children were familiarized with an equivalent 30-second movie clip involving a snowman. On the third visit, 6 months later, all the children were shown both movie clips simultaneously while being eye tracked. When the children returned to the lab for the present spontaneous memory study, one month after the third visit, two pictures (a Snowman and a Crab) from the film sequences presented in the eye tracker booth on the earlier encounter were hanging on the wall behind the two machines. The pictures served as reminders for the eye-tracking sequence that the children in the Experimental Group had been presented to.

The productive vocabulary of the participating children was assessed by means of a Danish version of the MacArthur Communicative Development Inventory: Words and Sentences (CDI). The CDI was included in order to have an additional control that the children in the two groups could be considered equivalent with regard to their language abilities.

2.3 Procedure

The overall test procedure consisted of three phases in the following order: (1) Primary test – Spontaneous memories while waiting, (2) $Control_1$ – Spontaneous memories and memories for actions while playing, and (3) $Control_2$ - Explicit recall.

2.3.1 Primary Test – Spontaneous memories while waiting.

The parents had been carefully instructed not to talk about the previous visits to the lab. When the child and the parent were picked up in the waiting room by the Experimenter, the parents were given a written note reminding them that a camera would be running when they entered the lab. The note firmly instructed the parent not in any way to remind the child of what had taken place in the lab on the previous visits (for the Experimental Group), and not to initiate any conversation about the previous visits. If the child spontaneously mentioned anything related to the previous visit, the parent was instructed only to respond briefly and in confirmatory fashion, but not to follow up on any statements from the child.

When entering the lab room, the parent and child were seated at a large table approx. 4 meters from the eye tracking booth and approx. 3 meters from the two magic machines that were placed next to each other. The Experimenter apologized because she was expecting an important phone call that she would need to attend to if her phone rang. The Experimenter started to introduce the procedure for the session, but was then "coincidentally" interrupted by the (fake) phone call made by an assistant in the adjacent room. The Experimenter apologized and left the lab, leaving the child and the parent alone in the lab for three minutes while the child's behavior and speech were recorded for later analysis.

When the Experimenter returned to the lab after 3 minutes, she provided the remaining instructions for the current session. The parent was then asked to fill out a questionnaire. While the parent filled out the questionnaire, the Experimenter initiated a warm-up session, with the child being asked open-ended questions about their kindergarten (e.g., "Can you tell me about what you did in kindergarten yesterday?"). The purpose of the warm-up session was to make the child feel secure in order to facilitate spontaneous talking while playing alone in front of the two machines in

the next test phase. When the child responded freely to the questions, the Experimenter moved on to the first of the two control phases.

2.3.2 Control$_1$ – Spontaneous memories and memories for actions while playing.

In the first control phase we wanted to test the children's spontaneous memories as well as their memories for actions when left to play alone with the two "magic" machines for a fixed 5 minutes period. The parent was briefly instructed to fill out a questionnaire, and then the Experimenter said to the child: "Your mum/dad will have to fill out some papers. In the meantime you can play here on the floor with the things we have got here, right? You don't have to be quiet, just play along." The child was then placed right in front of the two "magic" machines. Behind the "machines" an assistant was now present (she entered when the Experimenter returned from the phone call). The assistant's job was to make sure that the "machines" worked if they were operated correctly by the children. The assistant never responded to questions. If a child asked questions of the Experimenter, the Experimenter responded in a positive and acknowledging manner (for instance, "Yeah, that's right, that was exciting") while never (a) mentioning any words related to the operation of the machines, or (b) encouraging the child to remember anything. If the child produced a sentence that required a response from the Experimenter (e.g., "Why doesn't the machine work?" or "Where is X?"), the Experimenter responded in a friendly tone as follows: "I can't help you today, but you are free to play on your own." During the 5-minute period everything the child said or did was recorded for off-line analysis. When the 5 minutes had passed, the experiment moved on to the second control phase.

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2.3.3 Control$_2$ - Explicit intentional recall.

In the second control phase, each child was asked four specific questions (two questions for each machine) about how the two machines worked. The purpose of these questions was to ensure that the child in fact was capable of remembering the target event. The four questions were the following:

1. Does this machine make things small? [pointing to the Magic Shrinking Machine]
2. Can you wash clothes with this machine? [pointing to the Magic Shrinking Machine]
3. Can you make food with this machine? [pointing to the Crazy Duplicator]
4. Does this machine make two alike? [pointing to the Crazy Duplicator]

For two of the questions (Q1 and Q4), the correct answer was "yes", whereas the correct answer for the other two questions (Q2 and Q3) was "no". The questions were asked either in the order 1, 2, 3, 4, or 2, 1, 4, 3 (balanced between subjects). If the child did not reply, the question was repeated once. If the child still did not respond, the Experimenter moved on to the next question.

The test session ended by showing the child how each of the machines worked in order to avoid a potentially frustrating ending, especially for the children in the Control Group. No scoring was conducted during this last sequence.

Besides the actual testing described above, we also asked the parents to fill out a Danish version of the MacArthur Communicative Development Inventory: Words and Sentences (CDI). For the children in the Experimental Group the CDI was assessed by their parent in relation to the third and last visit when participating in the to-be-remembered experiment, that is, when the children were 45 months of age. For the children in the Control Group the assessment was conducted by their parents in relation to the present study, that is, one month later at the age of 46 months. We did not consider this age difference crucial.

2.4 Scoring and Data Reduction

2.4.1 Scoring: Primary test – Spontaneous memories while waiting.

The children's verbal productions were scored in two different ways: by Word List, and by Coding Scheme. In the following each of these scoring approaches are presented.

2.4.1.1 Scoring by Word List.

From the recordings a primary scorer scored verbally communicated spontaneous memories related to the to-be-remembered experiments from the children based on a Word List (see Appendix C). The Word List was developed as the study went on. The Word List consisted of any words or utterances that were regarded by the primary scorer as referring to the to-be-remembered experiments.

The Word List was an extended version of the check list that was used by Simcock and Hayne (2002). The reason for using an extended version was twofold: First, the check list developed by Simcock and Hayne (2002) was only related to the MSM but not to the CDC, and not to the two film sequences. Consequently, the original check list had to be extended in order to include words related to the latter two parts of the to-be-remembered material. Second, during the scoring of both the replication study (Dahl et al., 2014) and the present study, it soon became apparent that some of the utterances regarded by the primary scorer as clear indications of memory of the to-be-remembered experiments would *not* be captured by check lists that exclusively referred to the devices involved. For instance, one child said "Dad, I have been…yes I have been here so many times!" Another child said: "Where is the other lady? Where is the one with the glasses?" (referring to the assistant that was sitting behind the machines during the to-be-remembered experiments, but who was *not* present in the first test phase of the present study). And a third child said: "We *used* to sit there" [while pointing to the chair in the eye tracker booth where the children watched movies]. None of these utterances would be scored as indications of memory when using the Word List

solely referring to the devices in isolation. However, for someone familiar with the to-be-remembered experiments, these utterances appeared to be clear indicators of memories of the original events. In order to remedy these problems, we decided to score any utterance regarded by the primary scorer as clearly indicating memory of the to-be-remembered experiments.

The scoring was done as follows: Any mentioning of a word/utterance from the Word List (see Appendix C) *or* utterances clearly indicating memory (cf. examples given above) was given the score of "1". For each child a sum score was calculated.

In order to decide whether a given utterance was an indicator of memory of the to-be-remembered experiments, the primary scorer could not be naïve to the original experiments but had to know about them in detail. The downside of this requirement was that the primary scorer might have been biased. In order to control for this potential problem, a secondary scorer re-scored 90% of all the recordings (for all phases, that is: *Primary Test – Spontaneous memories while waiting, Control$_1$ – Spontaneous and motor memories while playing,* and *Control$_2$ - Explicit recall*). The secondary scorer did not know whether each child was from the Experimental Group or the Control Group. Since no drop outs were available for training purposes, the first 10% of all recordings were used to train the secondary scorer by means of the scoring manual made by the primary scorer. The interrater agreement of the remaining 90% of the data material was 93.4% and the two scorings correlated highly (r = .98, Pearson), indicating that the scorings of the primary scorer were indeed reliable.

2.4.1.2 Scoring by Coding Scheme.

We developed a comprehensive Coding Scheme aimed at capturing verbal utterances with mnemonic content broadly, including utterances that might not be captured by the Word List. Each three-minute video sequence from the "waiting" phase was divided into 18 time-slots of ten seconds' duration each. For each ten second time-slot the scorer had to reply to seven specific

questions regarding possible mnemonic content in the verbal utterances. The seven questions concerned the following seven aspects: (1) *language*, (2) *gestures*, (3) *reliving*, (4) *action details*, (5) *spatial details*, (6) *social details*, and (7) *perceptual details*. The exact wording of the seven questions was as follows:

(1) Does the child by means of *language* refer to knowledge that can only originate from a previous visit (e.g., by expecting something to happen, or to details that cannot be derived from the immediately present)?

(2) Does the child by means of *gestures* refer to knowledge that can only originate from a previous visit (e.g., by expecting something to happen, or to details that cannot be derived from the immediately present)?

(3) Does the child's verbal and/or non-verbal behavior indicate that the child mentally *relives* parts of a previous visit (e.g., by imitating earlier actions or by expressing enthusiasm or joy originating from a previous visit)?

(4) Does the child refer to specific *action details* from a previous visit (e.g., procedures or actions)? Only details that cannot be derived from the immediately present counts.

(5) Does the child refer to specific *spatial details* from a previous visit (e.g., where he/she used to sit or where some apparatus used to be? Only details that cannot be derived from the immediately present counts.

(6) Does the child refer to specific *social details* from a previous visit (e.g., by asking for specific persons currently absent). Only details that cannot be derived from the immediately present counts.

(7) Does the child refer to specific *perceptual details* from a previous visit (e.g., by stating how something looks like – i.e. "it turns"). Only details that cannot be derived from the immediately present counts.

For each ten second time-slot, the scorer should ask the seven questions outlined above. Whenever the response was "yes", the scorer gave the score "1". In case a single utterance involving mnemonic material extended across two (or more) ten second time-slots, only the scorings from the first time-slot counted. For each of the seven questions, a sum score based on the results from the 18 ten second time-slots was calculated (range: 0-18). Thus, for each child seven sum scores were derived. Note that the possible responses to the seven questions are not mutually exclusive. For instance, one of the children spontaneously uttered while pointing: "You turn on the heart" [referring to a pink 'heart' that is actually a lamp located on top of one of the machines]. This utterance resulted in the score "1" to questions number 1, 2, 3, and 4, but not 5, 6 and 7.

Finally, after having carried out the score for all 18 ten second time slots, the scorer should respond "yes" or "no" to a final question regarding whether she thought the child had been in the lab before based on his or her verbal utterances.

The scoring by Coding Scheme was conducted by two scorers, one primary and one secondary scorer, of which none had been involved in the scoring by the Word List. Both scorers were carefully instructed about the to-be-remembered studies, but were naïve regarding the fact that some of the children (the Control Group) had never been in our lab before. After having been trained together on the scoring manual, the secondary scorer re-scored 20% of all the participating children. Interrater agreement was very high (99.8 %), and the two scorings correlated highly (r = .91, Pearson).

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2.4.2 Scoring: Control$_1$ – Spontaneous memories and memories for actions while playing.

The spontaneous verbal utterances were scored in the same manner as the Word List scoring in the "Spontaneous memories while waiting" section.[3]

With regard to the memories for actions, both the number of correct target *actions* produced and the number of target actions in the correct *sequence* were scored. The child received a "1" for each target action produced correctly. They only got a score for producing each target action once. Similarly, the child received a "1" each time he/she produced two target actions in the correct sequence. For each child a total score for both machines was then calculated for both *actions* (range: 0-10) and *sequences* (range: 0-8).

2.4.3 Scoring: Control$_2$ - Explicit intentional recall.

The child received a "1" for each correct answer to the four control questions. A total score indicating the number of correct replies was then calculated for each child (range: 0-4).

3.0 Results

By means of a one-way ANOVA with Condition (Experimental Group vs. Control Group) as between-subjects factor and CDI score as the dependent variable, we first analyzed whether the Experimental Group and the Control Group could be considered equivalent with regard to their productive language. The analysis revealed that the two groups were very close in performance ($M_{\text{Exp\_Words}}$ = 638.7, *SD* = 70.6; $M_{\text{Con\_Words}}$ = 644.1, *SD* = 55.1, *F* <.12).[4]

[3] The number of verbal utterances produced in the 'while playing' phase, were so few that we did not consider it worthwhile also to employ the comprehensive scoring by Coding Scheme used in the primary test.

[4] Despite great efforts we did not receive CDIs for four children in the Control Group. Consequently, the comparison between the Experimental Group and the Control Group with regard to CDI scores was only based on the 25 children in the Control Group for whom we had CDI data.

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3.1 Primary Test – Spontaneous Memories While Waiting

We first present the results based on the *Word List* scoring and then the results derived from the *Coding Scheme*.

3.1.1 Primary test – Word List.

By means of a one-way ANOVA with Condition (Experimental Group vs. Control Group) as a between-subjects factor and number of spontaneous memories as indicated by the number of words uttered from the Word List as the dependent variable, we analyzed whether the children in Experimental Group would produce more spontaneous memories than the children in the Control Group while they were waiting for the Experimenter to return from the phone call. This analysis revealed that the children in the Experimental Group produced reliably more spontaneous memories relating to the target events than the children in the Control Group ($M_{\text{Prod-Word-List-Exp-Wait}}$ = 2.87, *SD* = 3.23; $M_{\text{Prod-Word-List-Con-Wait}}$ = 1.00, *SD* = 1.04; $F(1, 65) = 8.96$, $p = .004$, $\eta_p^2 = .12$).

3.1.2 Primary test – Coding Scheme.

By means of seven one-way ANOVAs, all with Condition (Experimental Group vs. Control Group) as a between-subjects factor and the respective sum scores for each of the seven questions from the Coding Scheme as dependent variables, we analyzed whether the children in the Experimental Group would show higher sum scores than their equally aged peers in the Control Group (see Table 1).

……

Table 1

……

The results revealed that the children in the Experimental Group obtained significantly higher sum scores for six out of the seven variables compared to the children in the Control Group. For the remaining variable (#6 *Social details*), the tendency was the same, but the difference was not significant, most likely because very few statements were coded in this category. Thus, overall the children in the Experimental Group spontaneously and without being asked directly produced reliably more mnemonic utterances relative to their same-aged peers in the Control Group while waiting for the Experimenter to return.

Finally, the scorer had assessed whether she based on the utterances scored on the Coding Scheme believed that each child had been in the lab before or not. Of the 38 children in the Experimental Group whom had all been in the lab, the scorer judged 26 of them to have been in the lab, and of the 29 children in the Control Group of which none of them had been in the lab before, the scorer judged 7 of them to had been in the lab before. A Mann-Whitney test revealed that children from the Experimental Group were significantly more likely to be judged as having been in the lab before compared to the children in the Control Group, $U = 795.00$, $z = 3.57$, $p < .001$, $r = .44$.

3.2 Control$_1$ – Spontaneous Memories and Memories for Actions While Playing

First, we repeated the Word List based analysis from above, but this time with data from the second test phase where the children were playing on their own in front of the two machines. The one-way ANOVA with Condition (Experimental Group vs. Control Group) as a between-subjects factor and number of spontaneous memories based on the Word List as the dependent variable revealed that although the children in the Experimental Group ($M_{\text{Prod-Word-List-Exp-Play}} = 1.84$, $SD = 2.53$) tended to produce more spontaneous memories than the children in the Control Group ($M_{\text{Prod-Word-List-Con-Play}} = 1.14$, $SD = 1.48$), the difference was non-significant, $F(1, 65) = 1.78$, $p = .19$, $\eta_p^2 =$

.03. Most likely this reflects that this measure was at floor level in both conditions, due to the very small amount of utterances being produced during this phase.

We now turned to the analysis of the children's ability to remember the specific actions and sequences of actions from the two machines. By means of a one-way ANOVA with Condition (Experimental Group vs. Control Group) as the between-subjects factor and the number of correctly produced target *actions* as the dependent variable, we first analyzed whether the children in the Experimental Group would remember more *actions* than their peers in the Control Group. The analysis revealed that the children in the Experimental Group produced significantly more correct target actions ($M_{\text{Actions\_Exp}} = 4.87$, $SD = 2.59$) than the children in the Control Group ($M_{\text{Actions\_Con}} = 1.34$, $SD = 1.01$), $F(1, 65) = 47.94$, $p < .001$, $\eta_p^2 = .42$). By means of a similar ANOVA again with Condition (Experimental Group vs. Control Group) as the between-subjects factor, but this time with the number of correct *sequences* of actions as the dependent variable, we then analyzed whether the children in the Experimental Group would also produce more correct *sequences* of actions than their peers in the Control Group. This analysis revealed that this was indeed the case. Again the children in the Experimental Group produced significantly more correct sequences of actions ($M_{\text{Sequenes\_Exp}} = 3.16$, $SD = 1.85$) than the children in the Control Group ($M_{\text{Sequences\_Con}} = 0.03$, $SD = 0.19$), $F(1, 65) = 81.47$, $p < .001$, $\eta_p^2 = .56$). Thus, the children in the Experimental Group produced reliably more target actions as well as reliably more correctly ordered sequences of actions than the children in the Control Group.

3.3 Control$_2$ - Explicit Intentional Recall

Finally, we wanted to examine how the children in both groups fared with regard to the four explicit control questions. A one-way ANOVA with Condition (Experimental Group vs. Control Group) as the between-subjects factor and the number of correct replies as the dependent variable

revealed that the children in the Experimental Group produced significantly more correct replies ($M_{\text{Recall\_Exp}}$ = 3.18, *SD* = 0.87) than the children in the Control Group ($M_{\text{Recall\_Con}}$ = 1.83, *SD* = 0.89), $F(1, 65) = 39.47$, $p < .001$, $\eta_p^2 = .38$. Thus, as expected, the children in the Experimental Group clearly remembered the function of the machines, whereas the children in the Control Group fared no better than chance level.

4.0 Discussion

We have introduced a new method for examining spontaneous (unprompted) memories in young children and shown that it is possible to induce spontaneous memories in a controlled lab setting in 3.5-year-old children. While the children were waiting for the Experimenter to return we recorded any verbal utterance produced spontaneously by them during the three-minute waiting period, and subsequently scored these utterances by using two encompassing scoring approaches: A comprehensive Word List and a detailed Coding Scheme involving seven distinct questions aimed at capturing possible mnemonic material related to the original event. The results were clear. Overall the children in the Experimental Group spontaneously produced significantly more verbal references to the previously experienced episodes in the lab compared to the children in the Control Group.

During the first Control Test (Control_1), the children in the Experimental Group produced significantly more target actions from the original experiment as well as significantly more target actions in the correct sequence than the children in the Control Group. And during the second Control Test (Control_2), the children in the Experimental Group produced significantly more correct voluntarily recalled replies when confronted with the explicit control questions regarding the (hidden) functions of the two 'magic' machines.

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We begin by discussing the results derived from the explicit control questions from $Control_2$. Although these were placed last in the sequence of tests in order to avoid influencing the preceding key tests on spontaneous remembering, they provide an important basis for interpreting the results obtained in the Primary Test, by documenting memory for the prior visits in the experimental group but not the control group.

More specifically, the results obtained by means of the control questions in $Control_2$ are important in at least two respects: First, the fact that the children in the Control Group fared no better than chance provides evidence that the explicit questions could not be answered by means of on-line reasoning, but required that the children actually had experienced and were able to recall the to-be-remembered events. Second, the superior performance of the children in the Experimental Group relative to the children in the Control Group shows that the children in the Experimental Group were indeed capable of remembering aspects of the original event. This evidence serves as a precondition for the investigation of possible spontaneous memories during the primary test.

With regard to the results obtained in the Primary Test while the children were waiting for the Experimenter to return, we first consider whether the verbal references to the original experiment qualify as spontaneous memories, which we defined as *verbally produced, environmentally cued,* and *unprompted* memories. For a number of related reasons, we argue that this is the case.

First, there were no demand characteristics with regard to memory for the children in the Primary Test. It seems unlikely that the children at that point in time felt inclined to deliberately recall anything in particular, because no questions were asked (or implied) and the children were just waiting for the Experimenter to return. In this respect the present study differs critically from previously conducted experimental studies on this topic, in which observations of 'spontaneous' memory reports always have been in the context of explicit testing. For example, when Priestley and colleagues (Priestley et al., 1999) investigated the possible impact of reminders and context

reinstatement on preschool children's memory of "Visiting a Pirate", several of the children 'spontaneously' talked about the to-be-remembered event during the reinstatement session one day before the test interview. However, the reinstatement session employed in the study by Priestley et al. (1999) clearly involved prompting as evidenced by the instruction to the children:

> […]. Let's look around at everything because tomorrow a lady is going to ask you all about when you went to visit the pirate, and having a look now might help you remember. Have a good look around and try and remember everything you did. (p. 1009)

The same is the case for any other experimentally based study we know of, in which 'spontaneous' memories were recorded. In contrast, the Primary Test of the present study did not involve any prompting from the Experimenter, since no instructions were given during or prior to the test.

Second, the parents were specifically instructed (i) not to ask any questions about the original experience in the lab, and (ii) not to follow up on any verbally produced material from the children referring to the previously experienced episodes in the lab. Hence, in the present study prompting from the parents was ruled out.

Third, by bringing back the children to the exact same lab setting, involving the same Experimenter, the design effectively provided a distinctive feature match between the original to-be-remembered event and the context for recall that has been considered crucial in order to facilitate episodic memory in general (Hayne, 2004; Newcombe et al., 2007) and involuntary memories in particular (cf. Berntsen et al., 2013). Thus, there is reason to believe that the spontaneous verbalizations produced by the children in the Experimental Group were indeed environmentally cued, consistent with our definition.

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Fourth, the fact that the children in the Experimental Group clearly outperformed the children in the Control Group with regard to the number of verbal references to the original episodes in the lab indicates that simple on-line reasoning was not sufficient and, thus, that the children's spontaneous reports reflected actual memory.

In short, the verbal utterances provided by the young children during the Primary Test appear to be clear examples of verbally produced, environmentally cued, and unprompted memories. Although some prior studies have shown 'spontaneous' verbal memory reports from young children, they have always been preceded by some sort of prompts, in contrast to the present work. Similarly, although several lines of infant memory research do not involve any instruction or prompting on the Experimenter's side, such as for instance Rovee-Collier's seminal conjugate reinforcement paradigm (for a review, see Rovee-Collier & Cuevas, 2009), the memory demonstrated in young infants in these studies would not qualify as spontaneous memory in the present context by being *non*-verbal and thus not satisfying the requirement of being explicit, verbal reports.

4.1 Findings from the control$_1$ test: Verbal and action memory

Although the results from the verbal part of the Control$_1$ Test revealed a trend in the expected direction, the children in the Experimental Group did not verbally produce significantly more spontaneous memories than their peers in the Control Group. This may have at least two reasons. First, because this was the second test phase, the children may already have said what they wanted to with regard to the to-be-remembered material during the preceding Primary Test. Second, contrary to the Primary Test, children in the Control$_1$ Test phase were sitting on their own in a 'play setting' while the adults present were occupied with other tasks and were, therefore, little available for conversation. Thus, the play setting constituting the Control$_1$ Test was probably less facilitating

for spontaneous verbalizations from the children, leaving the data from this phase of the experiment at floor level.

Considering the memory for actions in the $Control_1$ Test, the results were clear: The children in the Experimental Group were far more inclined to re-enact the target actions as well as the correct sequences of actions than the children in the Control Group. This is in accordance with other studies where young children have demonstrated action memories for even longer retention intervals (e.g., Bauer, Wenner, Dropik, & Wewerka, 2000; Simcock & Hayne, 2002).

4.2 Theoretical implications

The present study shows that when exposed to sufficiently distinctive environmental cues related to a previously experienced event, young children are indeed capable of producing, verbal spontaneous (unprompted) memories. How would these findings relate to 'adult' involuntary autobiographical memories? Are the children's spontaneous memories as demonstrated here simply another version of this phenomenon studied in adults? In order to be classified as 'adult' involuntary memories, the children's memories should have "[…] come to mind with no preceding conscious attempt at retrieval." (Berntsen, 2009, p. 2). We acknowledge that we have no direct evidence for this. However, we have reasons to assume that at least some (if not most) of the spontaneous memories may have been recalled involuntarily by the young children. First, young children have difficulties with intentionally retrieving verbal autobiographical memories (e.g., Simcock & Hayne, 2002). Thus, it would seem most likely that their references to a past experience would be the result of an unintentional associative retrieval process rather than intentional search. Second, as is the case in general for adult involuntary memories (Berntsen, 2009), the memories reported here were retrieved in response to environmental cues. No prompts of any kind were given, but at the same time the children were immersed in a context containing numerous highly

distinctive cues referring specifically to the to-be-remembered events. Because all the facilitating characteristics were present they constituted an ideal setting for the activation of involuntary memories, according to research conducted with adults (Berntsen, 2009). Furthermore, although we have no direct evidence that the memories were subjectively experienced as involving little retrieval effort, we also have no indications in the recorded verbal reports that the children actually were trying to remember. For example, none of the children implied in the conversation with their accompanying parent that they were trying to remember the previous visit, nor did any of them ask for the adult's help (or indicate the need for help) in relation to remembering what took place. In other words, no aspect of the verbal memories provided by the children in the Experimental Group appears to contradict the criteria for 'adult' involuntary memories as defined by Berntsen (2009), by indicating strategic search. Thus, although we cannot rule out the possibility that the unprompted spontaneous verbalizations in principle could have originated from a child's deliberate attempt to recall a certain memory, we find it, for the reasons given here, more likely that they generally did not attempt to recall aspects of the previous visits voluntarily.

In a broader perspective, our findings have implications for the manner in which researchers think about episodic memory early in life. The distinction between episodic and semantic memory was introduced by Tulving (1972) more than 40 years ago. Although the distinction is still debated, it has found its way into many modern textbooks on memory. Research on involuntary memory retrieval adds another dimension to be considered in relation to research on episodic memory. For instance, if involuntary memories – or at least precursors to involuntary memories in the form of spontaneous memories − are indeed present in young children, we may have to reconsider the prevailing view that episodic memories are an ability that develops later in life (e.g., Tulving, 1984). The prevailing view seems to rely on an implicit assumption that episodic memories by

default are results of deliberate, voluntary recall, but this is unlikely to be the only way that episodic memories appear in the child's mind, given the present findings.

We believe that the results obtained in the present study warrant further studies on spontaneous memories employing the basic idea of using the laboratory as a cue-specific context for inducing spontaneous memories. This would also help to clarify some of the questions that the present study leaves unanswered. First, even though a high degree of match with regard to specific cues between the to-be-remembered event and the context for recall seems crucial in order to facilitate spontaneous memories, the present study does not clarify the *relative* importance of different cues. For instance, what is the relative importance of the experimenter, the lab room, or the specific props used, etc.? Further research is clearly needed in order to disentangle these questions. Second, in the present study, the to-be-remembered event was not a single, unique event experienced only once. Rather, it consisted of up to three visits. We need to know whether the results would replicate in case the to-be-remembered event was a single, unique event. Third, in the present study we examined spontaneously arising memories in 3.5-year-olds. Future research should examine whether it is possible to induce spontaneous memories in even younger children following the methodology used here. If we were able to demonstrate the presence of spontaneous memories in even younger children, it would help to substantiate the claim that involuntary memories may be a basic mode of remembering prevalent in young children (e.g., Berntsen, 2012) given the well-known difficulties very young children have in relation to intentionally recalling past events. We believe that the present paradigm and the results obtained open a promising line of research for investigating such important questions.

References

Ashmead, D.H., & Perlmutter, M. (1980). Infant memory in everyday life. *New Directions for Child and Adolescent Development, 10,* 1-16.

Bauer, P.J., Kroupina, M.G., Schade, J.A., Dropnik, P.L., & Wewerka, S.S. (1998). If memory serves, will language? Later verbal accessibility of early memories. *Development and Psychopathology, 10,* 655-679.

Bauer, P.J., van Abbema, D.L., Wiebe, S.A., Cary, M.S., Phill, C., & Burch, M.M. (2004). Props, not pictures, are worth a thousand words: Verbal accessibility of early memories under different conditions of contextual support. *Applied Cognitive Psychology, 18,* 373-392.

Bauer, P.J., Wenner, J.A., Dropik, P.L., & Wewerka, S.S. (2000). Parameters of remembering and forgetting in the transition from infancy to early childhood. *Monographs of the Society for Research in Child Development, 65* (4, Serial No. 263).

Bauer, P.J., Wenner, J.A., & Kroupina, M.G. (2002). *Journal of Cognition and Development, 3,* 21-47.

Bauer, P.J., & Wewerka, S.S. (1995). One- to two-year-olds' recall of events: The more expressed, the more impressed. *Journal of Experimental Child Psychology, 59,* 475-496.

Berntsen, D. (1996). Involuntary autobiographical memories. *Applied Cognitive Psychology, 10,* 435-454.

Berntsen, D. (2009). *Involuntary autobiographical memories: An introduction to the unbidden past.* Cambridge: Cambridge University Press.

Berntsen, D. (2010). The unbidden past: Involuntary autobiographical memories as a basic mode of remembering. *Current Directions in Psychological Science, 19,* 138-142.

Berntsen, D. (2012). Spontaneous recollections: Involuntary autobiographical memories are a basic mode of remembering. In D. Berntsen & D.C. Rubin (Eds.), *Understanding autobiographical memory: Theories and approaches* (pp. 290-310). Cambridge: Cambridge University Press.

Berntsen, D., Staugaard, S.R., & Sørensen, L.M.T. (2013). Why am I remembering this now? Predicting the occurrence of involuntary (spontaneous) episodic memories. *Journal of Experimental Psychology: General, 142,* 426-444.

Dahl., J.J., Kingo, O.S., & Krøjgaard, P. (2014). *The Magic Shrinking Machine revised: The presence of props at recall facilitates the ability to use newly acquired words to describe 6-month-old events in 3-years olds.* Manuscript in preparation.

Dufresne, A., & Kobasigawa, A. (1989). Children's spontaneous allocation of study time: Differential and sufficient aspects. *Journal of Experimental Child Psychology, 47,* 274-296.

Fivush, R., & Hamond, N.R. (1989). Time and again: Effects of repetition and retention interval on 2-year-olds' event recall. *Journal of Experimental Child Psychology, 47,* 259-273.

Hayne, H. (2004). Infant memory development. Implications for childhood amnesia. *Developmental Review, 24,* 33-73.

Hudson, J.A. (1990). The emergence of autobiographical memory in mother-child conversation. In R. Fivush, & J.A. Hudson (Eds.), *Knowing and remembering in young children* (pp. 166-196). New York: Cambridge University Press.

Jack, F., Simcock, G., & Hayne, H. (2012). Magic memories: Young children's verbal recall after a 6-year delay. *Child Development, 83,* 159-172.

Jones, C.H., & Pipe, M.-E. (2002). How quickly do children forget events? A systematic study of children's event reports as a function of delay. *Applied Cognitive Psychology, 16,* 755-768.

Jones, D.C., Swift, D.J., & Johnson, M.A. (1988). Nondeliberate memory for a novel event among preschoolers. *Developmental Psychology, 24,* 641-645.

Kingo, O.S., Staugaard, S.R., & Krøjgaard, P. (2014). Three-year-olds' memory for a person met only once at the age of 12 months: Very long-term memory revealed by a late-manifesting novelty preference. *Consciousness and Cognition, 24,* 49-56.

Kingo, O.S., & Krøjgaard, P. (2014). *Young children's memory for movie sequences over a six month retention period revealed by eye tracing.* Manuscript submitted for publication.

MacDonald. S., & Hayne, H. (1996). Child initiated conversations about the past and memory performance by preschoolers. *Cognitive Development, 11*, 421-442.

Morris, G., & Baker-Ward, L. (2007). Fragile but real: Children's capacity to use newly acquired words to convey preverbal memories. *Child Development, 78,* 448-458.

Myers, N.A., Clifton, R.K., & Clarkson, M.G. (1987). When they were very young: Almost-threes remember two years ago. *Infant Behavior and Development, 10,* 123-132.

Nelson, K. (1989). *Narratives from the crib.* Cambridge MA: Harvard University Press.

Nelson, K., & Ross, G. (1980). The generalities and specifics of long-term memory in infants and young children. *New Directions for Child and Adolescent Development, 10,* 87-101.

Newcombe, N.S., Lloyd, M.E., & Ratliff, K.R. (2007). Development of episodic and autobiographical memory: A cognitive neuroscience perspective. In R.V. Kail (Ed.), *Advances in child development and behavior* (Vol. 35, pp. 37-85). San Diego, CA: Elsevier.

Newman, L.S. (1990). Intentional and unintentional memory in young children: Remembering vs. playing. *Journal of Experimental Child Psychology, 50,* 243-258.

Peterson, C., & Rideout, R. (1998). Memory for medical emergencies experienced by 1- and 2-year-olds. *Developmental Psychology, 34,* 1059-1072.

Poddubnaya, N.G. (1981). Distinctive features of involuntary memory in mentally-retarded 1st graders. *Soviet Psychology, 19,* 81-91.

Priestley, G., Roberts, S., & Pipe, M.-E. (1999). Returning to the scene: Reminders and context reinstatement enhance children's recall. *Developmental Psychology, 35,* 1006-1019.

Reese, E. (1999). What children say when they talk about the past. *Narrative Inquiry, 9,* 215-241.

Rovee-Collier, C., & Cuevas, N. (2009). The development of infant memory. In M.L. Courage & N. Cowan, (Eds.), *The development of memory in infancy and childhood* (pp. 11-41). Hove & New York: Psychology Press.

Simcock, G., & Hayne, H. (2002). Breaking the barrier? Children fail to translate their preverbal memories into language. *Psychological Science, 13,* 225-231.

Simcock, G., & Hayne, H. (2003). Age-related changes in verbal and nonverbal memory during early childhood. *Developmental Psychology, 39,* 805-814.

Smirnov, A.A., & Shlychkova, A.N. (1977). Relationship between voluntary and involuntary memory in recognition and recall. *Soviet Psychology, 15,* 74-91.

Sophian, C., & Hagen, J.W. (1978). Involuntary memory and the development of retrieval skills in young children. *Journal of Experimental Child Psychology, 26,* 458-471.

Todd, C.M., & Perlmutter, M. (1980). Reality recalled by preschool children. *New Directions for Child and Adolescent Development, 10,* 69-85.

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving & W. Donaldson (Eds.), *Organization of memory* (pp. 381-403). New York Academic Press.

Tulving, E. (1983). *Elements of episodic memory.* Oxford: Clarendon Press.

Tulving, E. (1984). Précis of elements of episodic memory. *The Behavioral and Brain Sciences, 7,* 223-268.

Watkins, O.C., & Watkins, M.J., (1975). Build up of proactive inhibition as a cue-overload effect. *Journal of Experimental Psychology: Human Learning and Memory, 1,* 442-452.

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Figure 1

Picture of the two machines as they were placed in the lab (left: The Magic Shrinking Machine; right: The Crazy Duplicator).

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Table 1

Sum scores and statistics for responses to each of the seven questions from the Coding Scheme related to the spontaneous produced utterances by the children in both groups while waiting for the Experimenter to return

	Experimental Group (n = 38)		Control Group (n = 29)		Statistics		
Question	*M*	*SD*	*M*	*SD*	*F*	*p*	η_p^2
#1: Language	2.16	2.63	0.31	0.60	13.76	<.001	.18
#2: Gesture	1.79	2.30	0.07	0.37	15.81	<.001	.20
#3: Reliving	2.16	2.63	0.31	0.60	13.76	<.001	.18
#4: Action details	1.50	2.37	0.14	0.35	9.42	.003	.13
#5: Spatial details	0.39	0.95	0.03	0.19	4.08	.048	.06
#6: Social details	0.26	0.60	0.07	0.26	2.65	.109	.04
#7: Perceptual details	1.00	1.83	0.07	0.26	7.36	.009	.10

NOTICE: this is the author's version of a work that was accepted for publication in Consciousness and Cognition. A definitive version was subsequently published in Consciousness and Cognition, 30, 24-35, on the 17th August 2014, DOI: 10.1016/j.concog.2014.07.017

Appendix A

Target actions for both machines

	MSM	CDC
1	Pulls down the handle	Takes a toy from the basket
2	Takes an object (X) from the bag	Puts X on the shelf and locks the door
3	Put X in the Machine	Puts the cymbal on the stick
4	Turns the handle	Takes the club and hits the cymbal
5	Opens the door and takes out X	Pushes the sliding door open and takes out X

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Appendix B

Objects used for each machine

	MSM	CDC
1	Giraffe	Squirrel
2	Playdough	Cup
3	Scarf	Belt
4	Can	Camera
5	T-shirt	Stove
6	Crayon	Rooster

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Appendix C

Word List (in alphabetical order)

MSM	CDC	Additional words
Bag	Basket	Animal
Box	Belt	Ball
Can	Camera	Beach
Crayon	Close	Crab
Door	Club	Disco
Giraffe	Copy Machine	Drum
Handle	Crazy	Flat
Light	Cup	Girl/Woman/Lady
Little	Cymbal	Hat
Magic Machine	Door	Heart
Open	Hit	Hop
Playdough	Out	Lamp
Pull	Push	Lights
Put	Put	Machine
Scarf	Ready	Movie
Shrink	Rooster	Pixie
Smaller	Shelf	Santa Claus
Thing	Sliding door	Snow
T-shirt	Squirrel	Snowman
Turn	Start	Two
Turn off	Stove	
Turn on	Toy	