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Thirty-five-month-old children have spontaneous memories despite change of context for retrieval

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Abstract

Many parents have experienced incidents in which their preschool child spontaneously (i.e., without prompting of any kind) recall a previously experienced event. Until recently, such spontaneous memories had only been examined in non-controlled settings (e.g., diary studies). Using a novel experimental paradigm, a previous study has shown that when young children are brought back to a highly distinct setting (same room, same experimenter, same furnishing), in which they previously experienced an interesting event (a Teddy *or* a Game event), spontaneous memories can be triggered. However, exactly *which* cues (or combination of cues) are effective for the children's memory, remains unknown. Here, we used this novel paradigm to examine the possible impact of contextual cues at the time of retrieval. We manipulated whether the 35-month-old children returned to the same room (n = 40) or to a different, but similarly furnished, room (n = 40) after one week. The results revealed that although the children returning to a new room produced fewer spontaneous memories than the children returning to the same room, the difference was not significant. Interestingly, despite changing rooms, the children still produced spontaneous memories**.** Taken together the results may shed new light on the mechanisms underlying childhood amnesia.

Keywords: spontaneous memories, episodic memories, contextual cues, childhood amnesia

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1. Introduction

For decades, researchers interested in memory and the development hereof have sought to map out the developmental course of the ability to remember previously experienced events. Today, we know that children and even infants are capable of remembering events over longer delays (see e.g., Bauer, 2007). This knowledge has been an important step in order to understand the phenomenon of childhood amnesia. The term *childhood amnesia* refers to the inability in adults to recall memories of specific events from the first years of their lives (e.g., Bauer, 2015; Pillemer & White, 1989). Due to the many studies providing evidence of memory in early childhood, we now know that this phenomenon is not due to an inability to form memories in the first place. Rather, childhood amnesia should probably be attributed to a multitude of contributing factors including *neurological development* (Bauer, 2008*), socio-emotional development* including *maternal reminiscence styl*e (Fivush, Haden, & Reese, 2006; Nelson & Fivush, 2004), the development of a *cognitive self* (Howe, 2003), differences in basic attentional and cognitive orientation, that is, the *different lenses explanation* (Bauer, 2007) including *language development* (Dahl, Kingo & Krøjgaard, 2015; Simcock & Hayne, 2002), as well as *forgetting* (Bauer, 2015; Hayne & Jack, 2011). What remains unknown seems to be the relative contribution of these factors and how they may interact.

So far, the predominant method for investigating childhood amnesia has been to *ask* children or adults to recall and talk about their past experiences (Hayne, Scarf, & Imuta, 2015). However, in order to comply with this standard methodology, the subject – regardless of age – would have to engage in a deliberate and strategic retrieval process requiring executive control involving activity in the frontal lobes. Meanwhile, the frontal lobes are

known to mature late in the ontogenesis (e.g., Johnson, 2005) making the default task of deliberate and strategic recall harder for young children than for adults.

Deliberate and strategic retrieval is, however, not the only route to memories of past events. At times, such memories come to our mind suddenly and uninvited, almost 'out of the blue'. Such memories are referred to as *involuntary* or *spontaneous* memories and healthy adults frequently experience such memories in daily life, often triggered by distinct environmental cues (Berntsen, 1996, 2009). When dealing with young children, who are unable to report whether a memory is retrieved strategically or spontaneously, we define spontaneous memories from a third person perspective as (i) verbally produced, (ii) socially unprompted, and (iii) environmentally cued (Krøjgaard, Kingo, Dahl, & Berntsen, 2014). Involuntary or spontaneous retrieval differs from deliberate and strategic retrieval by being based primarily on simple associative mechanisms and is therefore less dependent on mature frontal lobes (Hall et al., 2014). Consequently, involuntary or spontaneous retrieval is likely to be less cognitively demanding and has recently been proposed to be a basic mode of remembering present early in the ontogenesis (Berntsen, 2009, 2012). Thus, for young children, spontaneous retrieval may constitute an easier path to past experiences. As a consequence, in young children, memories that may be inaccessible through voluntary retrieval may be reachable through the less demanding spontaneous retrieval route, in response to relevant distinctive cues. Following this, the number of childhood memories forgotten, as the children grow older, may have been underestimated. If so, this would have implications for our understanding of childhood amnesia. In the discussion we will return to this possibility.

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1.1 Spontaneous retrieval in children

Until very recently spontaneous recall in children had almost exclusively been documented using semi-structured methodologies, as for instance diary studies (e.g., Nelson & Ross, 1980; Reese, 1999; Todd & Perlmutter, 1980). One exception is an unpublished study cited in Leichtman (2006) in which children between 4 months and 3 years of age on 5 consecutive days were exposed to a puppet with an edible treat hidden in a mitten. When returning to the lab 3 or 6 months later, 12% of the 17-18 month olds and 45% of the 3-4 year olds spontaneously talked about the previously experienced event (Leichtman, 2006).[1]

Recently, a novel experimental procedure provided evidence that spontaneous memories can be induced in young children under controlled conditions (Krøjgaard, Kingo, Dahl, & Berntsen, 2014) – even for unique events (Krøjgaard, Kingo, Jensen, & Berntsen, 2017). The development of this novel experimental paradigm provides a unique opportunity for investigating spontaneous memories in children more closely. As the present study makes use of the same design as the one used in the most recent version of this paradigm (Krøjgaard et al., 2017), it is outlined here in some detail: A group of 35- and 46-month olds visited the lab twice separated by one week. At the first visit, the children were presented with one of two highly unique and entertaining events: either a *Teddy event*, involving two mechanical teddies capable of singing and wiggling with their ears, or the *Game event*, in which the children were invited to try two different types of throwing games for which they always won medals. When not used for demonstration, the props for each of the two events were locked away in their own distinct box. At the second visit, the children returned to the exact same

[1] Numerous infant studies have provided evidence, that infants by means of behavioral responses are capable of remembering aspects of previously experienced events without being socially prompted to do so (e.g., Perris, Myers, & Clifton, 1990; Rovee-Collier, Griesler, & Earley, 1985). However, these demonstrations of memory among infants should not be considered spontaneous memories as defined here, because the memory manifestations in these infant studies were not verbal but exclusively motor-based.

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setting and were left alone with their parent for two minutes right in front of the two opaque boxes of which they knew the contents of only *one* of the boxes. The parents had been carefully instructed not to prompt the children in any way during this waiting period, allowing us to record possible spontaneous utterances from the children for later analyses. Compared to an equivalent baseline measure obtained at the first visit prior to being presented with the given event, the children spontaneously talked about the event they had seen at the first visit, while they never talked about the event they had not seen when returning to the lab at the second visit (Krøjgaard et al., 2017).The 35-month-olds performed poorly relative to their 46-month-old peers, when asked control questions requiring strategic recall at the very end of the second visit, whereas age had little effect on the children's *spontaneous* recall.

While the recent study by Krøjgaard et al. (2017) showed that spontaneous recall can indeed be induced in young children, we do not know exactly what type of cues made the children spontaneously remember the target event. The experimental set-up used in Krøjgaard et al. (2017) allows us to investigate this more thoroughly. In the present study, we therefore focus on the possible impact of *contextual cues* (i.e., manipulating whether or not the children return to the same room). Focusing on cues is important not only when attempting to understand the mechanisms of spontaneous recall, but also, from a broader perspective, in relation to childhood amnesia to which we will turn in the discussion. In the following, we review the existing evidence on the possible impact of contextual cues for recall.

1.2 Are contextual cues important?

In a seminal paper, Tulving and Thomson (1973) proposed the *encoding specificity principle* stating that retrieval depends on the overlap between the information available during encoding and the information present at retrieval. Inspired by this principle, Pipe and

collaborators (among others) have examined the possible impact of returning to the exact location where the to-be-remembered event took place, when young children were asked to recall a previously experienced event (e.g., La Rooy, Pipe, & Murray, 2007; Pipe & Wilson, 1994; Wilkinson, 1988). La Rooy et al. (2007) for instance examined 5- and 6- year-olds' verbal recall of a 'visiting the pirate' event experienced six months earlier. The test interviews were conducted either in (a) a perfect-context reinstatement (same room, same objects), (b) an imperfect-context reinstatement (same room, but with some objects replaced), or (c) an imperfect-context (different room, no objects). The results revealed that being interviewed in the same room in which the to-be-remembered event had taken place reduced forgetting, and that children in the perfect-context reinstatement condition outperformed their peers in the two other conditions with regard to accuracy (La Rooy et al., 2007). Additional converging evidence has been obtained in the forensic literature in which returning to the original crime scene of alleged abuse led 3-14 year old children to provide additional details (Hershkowitz et al., 1998, although see Orbach, Hershkowitz, Lamb, Sternberg, & Horowitz, 2000; for a general review of context-facilitation in memory, see Smith, 2014).

Very little however, is known regarding the possible impact of contextual cues for *spontaneous*, verbal retrieval. In a diary study with 25-month-old children, Reese (1999) showed that spontaneous recall was predominantly evoked by cues from the environment (as opposed to verbal and internal cues). Reese (1999) did not distinguish between different environmental cues (e.g., objects vs. contexts), but two of the examples she provided involved specific contexts as cues (e.g., when passing a stadium, a child said *Go go go Otago*, a chant from a rugby game) suggesting that contextual cues may be salient.

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However, to our knowledge it has however never been investigated systematically whether contextual cues are also important when dealing with spontaneous retrieval in children. We set out to examine exactly this possibility.

1.3 The present study

In the present study we followed and extended the procedure developed by Krøjgaard et al. (2017) in which spontaneous memories of a previous lab visit were induced in young children by reinstating the context. Here we extend this paradigm to specifically examine the potential impact of contextual cues by manipulating which room the children returned to at their second visit (see Fig. 1).

Accordingly, at the second visit half of the children returned to the exact same room (Room A) with the exact same boxes (Same-Room Condition), whereas the other half returned to a new room (Room B) with the exact same boxes (Different-Room Condition). The reasoning behind the furnishing of the rooms was the following: We wanted to have the basic setup with the two adjacently arranged boxes present in both rooms. This was primarily to avoid possible ambiguities with regard to remembering the hidden props, which then could be based on either landmarks (e.g., 'inside the red box') or spatial placement (e.g., 'to the left'). Besides the arrangement of the two adjacent boxes, the two rooms were different and distinct (see Fig. 1): Whereas the far end in Room A was dominated by light-grey room dividers in soft cloth, the far-end in Room B was substantially dominated by the large floor-to-ceiling mat-black eye tracker booth in particle board. In addition, whereas the room dividers in Room A were positioned straight across the room, the eye tracker booth in Room B was positioned in a "V-configuration". Thus, because the far ends of the two rooms differed with respect to shape, size, color, and texture we assumed that the two rooms would be easily distinguishable.

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Because the original experiment already provided evidence that both 35-month-olds and 46-month-olds spontaneously remembered the target event, we decided to only focus on the youngest age group in the present study.

Since no evidence exists from controlled studies on spontaneous recall regarding the possible effect of contextual cues, our tentative hypothesis was based on the studies conducted using strategic verbal recall (e.g., La Rooy et al., 2007). We thus hypothesized that returning to a different room would reduce spontaneous recall. Our expectation was therefore that the children in the Different-Room Condition would produce fewer spontaneous memories of the target event compared with their peers in the Same-Room Condition.

2. The Experiment

2.1 Participants

Eighty 35-month-olds (45 female, M_{age} = 35.15 months, *SD* = .42; range: 34.13- 36.60 months) participated. The children were recruited from birth registries from the National Board of Health and were predominantly Scandinavian Caucasian living in families with middle to higher SES. All children were healthy, full-term, and had an Apgar score ≥7. The children were randomly assigned to one of two conditions: the Same-Room Condition (n = 40) or the Different-Room Condition (n = 40). In each condition half of the children (n = 20) were exposed to the Teddy event, whereas the other half (n= 20) were exposed to the Game event (see below). Seven additional children were tested but later excluded due to: fussiness (4); experimental error (2); speaking a foreign language at test (1). Each child received a small gift for participating when returning for the second visit.

2.2 Materials

Two sparsely furnished 16 m^2 rooms were used: Room A and Room B. Both rooms were located in the same corridor (see Fig. 1 as well as the previous description of the differences between the two rooms).

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In both rooms, along one side, two boxes were placed right next to each other: To the left a red metal box with doors and to the right a grey plastic box with a top lid. Both boxes had locks. Each box contained specific props to provide a unique and distinct experience dependent on whether the child had been allocated to the Teddy event (the red metal box) or the Game event (the grey plastic box). A table with chairs was placed along the opposite wall of the room to make sure that the child had a clear view to both boxes. All sessions were recorded for later coding.

The *red metal box* contained two distinct mechanical toy teddies: A blue elephant named Elly capable of singing a song while wiggling its ears when pressing a button; a light-brown colored dog called Alfred, who could sing a song while wiggling its ears and clapping its paws when activated. The *grey plastic bo*x contained props for two different games: A throwing game (involving three colored buckets and three soft balls), and a bowling game (involving plastic balls and ten pins).

2.3 Procedure

All children visited the lab twice separated by one week (± 1 day). For all children the first visit (T_1) took place in Room A. When returning for the test (T_2) the room was condition specific: The children in the Same-Room Condition were tested in Room A, whereas the children in the Different-Room Condition were tested in Room B. During recruitment, the parents were carefully informed that the study concerned spontaneous recall and they were instructed not to talk about the study and not in any way let the children know that the study was about memory. In case the child should ask about the visits, the parents were instructed to simply reply "I don't know". In addition we had ensured that none of the children had participated previously in any studies in our lab. The purpose was to avoid that the children would guess or be left with the impression that the study was about memory.

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2.3.1 T_1 – Encoding.

At the first visit (T_1) the procedure involved two steps: (1) A two-minute baseline measure, and (2) an encoding session involving the specific event to which the child had been allocated. When picked up in the waiting room, the parent was handed a written note reminding him or her not to initiate any conversation with the child and only to respond briefly without following up on any statements from the child during the baseline assessment. The child and the parent were taken to Room A and seated next to each other facing the two locked boxes. The experimenter then stated: "I have to do something, but I'll be right back." The child and the parent were left alone in front of the two boxes for exactly two minutes (timed by use of a stop watch). The sequence was recorded for subsequent coding and any verbal utterances produced by the child served as a baseline measure (see below).

When the two minutes had passed, the experimenter returned. A BLINDED version of the MacArthur Communicative Development Inventory: Words and Sentences (CDI) was handed out in order to assess the productive vocabulary of the children, and the parents were asked to return it at the second visit.[2] At the second step (the event specific encoding), each child was presented with *one* of the events: either the Teddy or the Game event. Both events lasted approximately six minutes. The basic idea was to engage the child in a funny and memorable event. Importantly, at no time during the encoding session, were the children left with the impression that they had to remember anything; the word 'remember' (or equivalent) did not appear in the two distinct event demonstrations. These precautions were made in order to avoid that the children would feel socially prompted to remember anything when returning for the test a week later.

[2] We failed to collect CDI reports from 4 of the children.

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2.3.1.1 The Teddy event. The experimenter opened the red metal box with a key and demonstrated the two very special teddies that could sing, clap, and wiggle their ears to the child. The child was encouraged to say which animals the teddies were, to say their names (Elly the elephant, and Alfred the dog), and to activate the teddies.

2.3.1.2 The Game event. The experimenter brought out the two games (a throwing and a bowling game) from the grey plastic box, one at a time. The child was asked whether he or she knew the name of the items and was encouraged to say it out loud and praised when doing so. No matter how the games went the child was praised and received a 'gold medal' for participating in each game.

2.3.2 T_2 – test.

The second visit (T_2) involved two steps: (1) a two minute test of spontaneous recall and (2) control questions involving strategic retrieval. The two minute test was an exact replication of the baseline procedure administered at T_1. The only difference (besides the change of location for half of the participants) was that this time, the children had actually been in the lab once before and had therefore experienced the contents of *one*, of the boxes, depending on which event the children had seen at T_1.

When the two minutes had passed, the experimenter returned to ask control questions to examine what the children could remember when asked directly about the event. The control questions were deliberately asked *after* the two-minute spontaneous memory test in order to conceal that the study was about memory until after the test for possible spontaneous utterances. The control questions used here were of a focused 'yes/no' format. For each of the two boxes (of which each child had only seen the contents of one), the child was asked two questions that required the child to search his or her memory to provide an answer. The order

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of the questions addressing the two events was balanced across subjects and conditions. The experimenter began by asking: "Remember last time you were here…:

Q1: "Did you see what was in the red cabinet/grey plastic box?" [If the response was "no", or if a "yes" was accompanied by a description of the contents, question #2 was left out. If only a "yes" or no response was given, then question #2 was asked]

Q2: "What was in the red cabinet/grey plastic box?"

2.4 Coding and data reduction

Two kinds of data were collected: (i) spontaneous verbal responses produced while waiting at both T_1-baseline and T_2-test, (ii) responses to the control questions at T_2. We first consider possible spontaneous verbal responses.

2.4.1 Coding of spontaneous verbal responses.

Central for the coding of spontaneous verbal responses was the two videos of two-minute duration from each child: One video from T_1-baseline and one from T_2-test. Prior to the coding, all video recordings had been edited so they only contained the two-minute excerpts from when the child and parent were left alone in the room. As a result, the coders were blind to which event a given child had seen, as well as whether a given video originated from T_1-baseline or from T_2-test. Finally, the coders were unaware of the two conditions and the related hypotheses.

Based on the coding strategy employed in Krøjgaard et al. (2017), all spontaneous verbal utterances produced by the children during the two-minute waiting time at both baseline and test were coded by two measures: a Word List and a Coding Scheme.

2.4.1.1 Coding by Word List. From the edited recordings the coders coded verbally communicated spontaneous memories related to the to-be-remembered events from the

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children based on a Word List (see Appendix A). The Word List consisted of words related specifically to each of the two events (Teddy and Game) and an additional Unspecific list referring to utterances indicating that the child had been in the lab before, but without specifically referring to one of the two events (e.g., when returning, one child said: "we did that last time too"). The Word List was fixed and developed prior to the coding. Any mentioning of a word from the Word List (see Appendix A) resulted in the score of either a "T" (Teddy), "G" (Game), or "U" (Unspecific) dependent of which of the three lists the word belonged to. Note that these distinctions were necessary as both the event specific scores, as well as the event-unspecific scores, were indicative of having been in the lab before. Sum scores were calculated for each child.

2.4.1.2 Coding by Coding Scheme. Following Krøjgaard et al. (2017), we also coded possible utterances by a Coding Scheme. The rationale was to obtain an additional measure in case there might be spontaneous verbal utterances indicative of memory for the events that would not be captured by the words from the fixed Word List. Each two-minute video sequence from both the T_1-baseline and the T_2-test "waiting" phase was divided into 12 time-slots of ten seconds' duration each. For each ten second time-slot the coder had to reply to seven specific questions regarding possible mnemonic content in the video segments. These questions concerned the following seven dimensions: (1) *language*, (2) *gestures*, (3) *reliving*, (4) *action details*, (5) *object details*, (6) *spatial details*, and (7) *social details*. The Coding Scheme was inspired by the coding of internal (episodic) details developed by Levine, Svoboda, Hay, Winocur and Moscovitch (2002) in order to distinguish between episodic and semantic components of memories of events. The exact wording of the seven questions was as follows:

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(1) Does the child by means of *language* refer to knowledge that originates from a previous visit?

(2) Does the child by means of *gestures* refer to knowledge that originates from a previous visit?

(3) Does the child's verbal and/or non-verbal behavior indicate that the child mentally *relives* parts of a previous visit?

(4) Does the child refer to specific *action details* from a previous visit?

(5) Does the child by means of specific *object details* refer to knowledge that originates from a previous visit?

(6) Does the child by means of specific *spatial details* refer to knowledge that originates from a previous visit?

(7) Does the child by means of specific *social details* refer to knowledge that originates from a previous visit?

For each question, each ten second time-slot could lead to either a single score or no score. For each of the seven questions, a sum score based on the results from the 12 ten second time-slots was calculated (range: 0-12). Thus, seven sum scores were derived for each child. Note that the possible responses to the seven questions were not mutually exclusive. To illustrate, when returning at T_2, one boy who had been presented with the Game event, pointed to the grey box and said "There is a bucket inside", which led to hits in dimension 1, 2, 3, and 6, but not in 4, 5, and 7.

The coding by Word List and the coding by Coding Scheme were conducted by one primary and one secondary coder for each condition. After being trained together on a coding manual, the primary coder coded all participating children, whereas the secondary coder re-

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coded 20% of the children. Interrater agreement was very high: Same-Room Condition: 99.5%; Different-Room Condition: 97.9%.

2.4.1.3 Coding of control questions. Here it was simply noted whether the child's answer was correct ('yes' or 'no'), and this part was therefore coded online by the experimenter. Re-coding was not considered necessary.

3. Results

3.1 Preliminary analyses.

An ANOVA with Condition (Same-Room vs. Different-Room) and Event (Teddy vs. Game) as between-subjects factors and the children's productive vocabulary as the dependent variable revealed neither main effects nor interactions (all *p*s >.18) indicating that the children in the groups did not differ with respect to productive vocabulary ($M_{\text{Same-room\_Teddy}}$ = 552.28, *SD* = 133.35; $M_{\text{Diff-room\_Teddy}}$ = 551.50, *SD* = 139.39; $M_{\text{Same-room\_Game}}$ = 534.95, *SD* = 137.17, $M_{\text{Diff-room\_Game}}$ = 487.74, SD = 112.53). This analysis was conducted to ensure that any possible difference in results obtained by means of the experimental manipulation between the two conditions could not be attributed to differences in the children's productive vocabulary.

3.2 Results from the Word List and Coding Scheme

The central part of the data was from the two-minute waiting periods at T_1-baseline and T_2-test. Based on our hypotheses, three questions were crucial: First, did the number of possible spontaneous verbal utterances obtained at the T_2-test differ reliably from the equivalent data obtained at the T_1-baseline? Second, were the possible spontaneous verbal utterances *congruent* (see below) or incongruent with the specific event (Teddy *or* Game), the child was presented with at T_1-baseline? And third, did the room that the children were tested in at T_2 affect the results?

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We define a *congruent* spontaneous utterance as referring specifically to the event (Teddy *or* Game) that the child was presented with at T_1-baseline (or by a condition *un*specific utterance just indicating that the child had been there before), and not to the other event, whereas an *incongruent* utterance refers specifically to the event to which the child was *not* exposed at T_1-baseline. Because the analyses focused on whether the children at T_2 spontaneously talked about the event (Teddy or Game) they had been presented with at T_1, and since the two events were counterbalanced across children and conditions, the two events were collapsed in the subsequent analyses (cf. Krøjgaard et al., 2017).

Table 1 displays the descriptive statistics and *t*-tests, from both events combined, based on the congruent spontaneous utterances (both from the Word List and the Coding Scheme) obtained while waiting for the experimenter to return at the T_2-test. Data from the measures obtained at T_1-baseline as well as incongruent measures from the T_2-test are not displayed, simply because there were *no* hits – except for a single incident. This single exception came from a boy from the Same-Room Condition who, during the T_1-baseline (i.e., *before* being presented with the Game event), talked about animals in cabinets. During the subsequent demonstration of the Game event, it turned out that this boy earlier the very same day, by sheer coincidence, had seen stuffed animals in cabinets! Hence, this boy talked about animals in cabinets while waiting and was credited (coding-wise correctly) by the naïve coder for doing so. Except for this single exception, no false positives were obtained. In addition, during the T_2-test there was not a single incident in which a child spontaneously talked about the event that the child had *not* seen at T_1. Consequently, the analyses from the congruent hits obtained at the T_2-test were generally analyzed by simple One-Sample *t*-tests tested against the test value of "0" (i.e., "no hits"), except in the Word List measure and in three dimensions in the Coding Scheme measure in the Same-Room Condition in which the test value were

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slightly above zero (equivalent to the exact means obtained in these scales as a consequence of the one boy mentioned previously and straight zeroes for all the remaining measures).

Overall, the results revealed that the children at the T_2-test in both conditions spontaneously and reliably talked about the event they had seen at T_1, whereas they never talked about the event they had not seen at T_1. The results were clear, systematic, and significant in both conditions and for both the Word List and the Coding Scheme (only the social dimension in the Same-Room Condition was not significant).

Did the room that the children were tested in at T_2 affect the results? When looking at the means obtained in the two conditions, there was a systematic tendency that the children in the Different-Room Condition obtained numerically lower sum scores for the spontaneous utterances (the social dimension was the single exception) relative to the peers in the Same-Room Condition (see Table 1). However, probably due to the large variance in the scores, this tendency was not statistically significant. Thus, contrary to our expectations, returning to a different context (the Different-Room Condition) did not have a reliable detrimental effect on the number of produced spontaneous utterances at the T_2-test.

As can be seen from Table 1, the obtained congruent scores for the seven Coding Scheme dimensions were highly systematic and clear. Because they addressed memory for the same underlying event, we expected them to be correlated with one another to some extent and, consequently, that they might be treated as a scale as was the case in the Krøjgaard et al., (2017) study. In the present dataset, an item analysis led to a Cronbach's α = .915, replicating Krøjgaard et al., (2017) and justifying treating the dimensions as a scale. We then computed a total sum score of hits based on sums of each of these seven dimensions (sum of condition specific *and* condition unspecific hits). First, we analyzed whether the results obtained by each of the dimensions would replicate when running the analysis on the

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computed sum scores. As expected they did. For the children in the Same-Room Condition (n = 40), the mean sum score of congruent hits (condition specific hits and unspecific hits combined) at the T_2-test (M = 2.85, SD = 3.75) clearly differed from the means obtained at T_1-baseline (One-Sample t-test tested against "0.13": $t(39) = 4.59$, $p < .001$, $r = 0.59$). Similarly, for the children in the Different-Room Condition (n = 40) the mean sum score of congruent hits (condition specific hits and unspecific hits combined) at the T_2-test (M = 2.45, SD = 3.59) also reliably differed from the means obtained at T_1-baseline (One-Sample t-test tested against "0": $t(39) = 4.32$, $p < .001$, $r = 0.57$). However, the sum scores obtained did not differ across conditions (independent samples t-test: $t[78] = 0.49$, $p = .627$, $r = 0.06$). Thus, the results based on the sum scores replicate the pattern of results obtained when looking at the individual dimensions: In both conditions, the children at the T_2-test reliably and systematically produced spontaneous utterances about the events they had been presented with at T_1-baseline, while never talking about the event they had *not* seen. Similarly, although the children returning to the same room for the test on average had higher sum scores than the peers returning to a different room, the difference was not statically significant.

3.3 Results from the Control Questions

The control questions addressed whether the children would respond correctly when asked directly about the contents of the two boxes. By means of non-parametric binomial tests (against $p = .50$, two-tailed) we analyzed whether the distribution of correct replies regarding the contents of the two boxes across conditions was significant. The 'known' box refers to the box to which the child was exposed to during T_1, whereas the 'unknown' box refers to the box to which the child was *not* exposed to at T_1. The results are displayed in Table 2.

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Overall, the children in both conditions tended to respond correctly when asked about whether they knew the contents of the "known" box (i.e., the box they had seen the contents of), whereas they only responded at chance level when asked about whether they knew the contents of the "unknown" box (i.e., the box, they had never seen the contents of).

In order to examine whether the results differed across conditions, we computed a sum score for the number of correct responses regarding whether the children knew the contents of each of the two boxes (the known and the unknown box; range 0-2). An independent samples *t*-test revealed that although the children in the Same-Room Condition tended to have slightly higher sum scores, the difference was not significant, $t(78) = 0.71$, $p = .478$, $r = .07$, $M_{\text{Sum\_score\_Same-Room}} = 1.25$, $SD = 0.49$; $M_{\text{Sum\_score\_Diff-Room}} = 1.18$, $SD = 0.47$. Thus, changing the room at recall did not affect how the children responded to the control questions.

4. Discussion

In accordance with previous studies using the same overall design (Krøjgaard et al., 2014; Krøjgaard et al., 2017), the results showed that spontaneous memories can indeed be induced in an experimental setting, and that 35-month-old children at the T_2-test spontaneously talked about the event they were presented with at T_1, whereas they never talked about the event, they had not seen. Further, the dimensions used for the Coding Scheme again turned out to constitute a reliable scale. By systematically replicating previous results regarding spontaneous memories, the present findings lend further support to the credibility of the new paradigm.

In the present study we expanded on the previous findings by specifically examining the possible impact of contextual cues operationalized here as having half of the children return to a different room at the test. Although the number of spontaneous memories was

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numerically smaller, returning to a different room did – in contrast to our prediction – *not* reliably reduce the number of spontaneous memories. Potentially, this null finding could be due to lack of statistical power. Although possible, we consider this unlikely. Even the largest effects size (r = 0.14) obtained from the comparison of the Word List measure outcome from the two conditions (see Table 1, last column), was 'small' from a conventional point (Cohen, 1988). Given the obtained *M*'s and *SD*'s for the two conditions, a power analysis showed that 190 subjects in each condition would have been needed in order to obtain a power of 0.8 for a two-tailed test with an α =.05. Thus, although the children in the Different-Room Condition numerically obtained fewer hits than their peers in the Same-Room Condition, the difference was of small magnitude, and therefore we find it unlikely that the results were due to lack of statistical power. Even if a study with about 190 subjects in each condition might reach a statistically reliable difference with p <.05 (as suggested by our power analyses), the effects of the manipulation is under all circumstances very small. It should also be noted that our sample sizes were in the range of the sample sizes normally used in this field.

Although no previous studies specifically have examined the possible impact of changing the context for spontaneous retrieval, other studies have found effects of contextual reinstatement, as reviewed in the introduction. For instance La Rooy et al. (2007), showed clear effects of changing the context at retrieval on children's memories. How should this discrepancy in results be explained? The design in La Rooy et al., (2007) and the present study differed in at least three respects, that is, age of the participants (5-6 year olds vs. almost 3-year olds), the retention interval (6 months vs. 1 week), and retrieval mode (strategic vs. spontaneous). In addition, the manipulation of context may have been stronger in the La Rooy et al. (2007) study. In the present study, the two rooms used in the Different-Room Condition differed with regard to their location in the corridor and the furnishing of the

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far end of each room. Theory predicts that in order to serve as a strong cue, the cue needs to be *distinct* (cf. Watkins & Watkins, 1975; Smith, 2014). In retrospect, the children's perception of the distinctiveness of the setting may have been mainly tied to the setup of the two boxes – which was preserved across the two rooms – rather than to the rooms as such. This agrees with the fact that very few of the children in the Different-Room Condition commented on returning to a different room. Although this is only anecdotal evidence, it may suggest that the change of room at test in the present study was not particularly prominent to the children. In hindsight, we regret that we did not – after the test was over – ask the children in the Different-Room Condition whether they had noticed the change of rooms. When considering the environmental cues in a broader perspective, many cues were actually the same across the two conditions (same campus, same parking lot, same waiting room, same corridor, and same two boxes in the test rooms). Thus, greater effects of the retrieval context manipulation might have been obtained with a more prominent difference between the encoding and retrieval contexts in the Different Room Condition.

4.1. Control questions

In general, the children reliably confirmed that they knew the contents of the box they had been exposed to during the first visit. In contrast, the children's responses to whether they knew the contents of the box, they had never seen the contents of, did not exceed chance level. These results are in accordance with the results obtained previously employing the same overall design and with children in the same age group (Krøjgaard et al., 2017).

Importantly, however, condition (i.e., Same-Room vs. Different-Room) had no effect on this pattern of results. Although the children in the Different-Room Condition numerically fared slightly worse than their peers in the Same-Room Condition, the difference was not significant. Thus, replicating the pattern in results from the spontaneous measures, changing

the room at retrieval did not reliably diminish the children's ability to respond to the control questions.

4.2. Broader implications

The present findings add to a growing literature showing that spontaneous memories are common in young children's lives and may be their most dominant way of rehearsing and remembering their personal past. Viewed from a broader perspective, these findings appear consistent with explanations of childhood amnesia centering on *forgetting* (Bauer, 2015; Hayne & Jack, 2011). Given the fact that the great majority of studies on children's memory of events have been based on children's strategic retrieval (i.e., asking the children, see Hayne, Scarf, & Imuta, 2015), in which the process of retrieval *by itself* is particularly demanding for young children, researchers may have underestimated the magnitude of young children's memories. Provided that this argument is valid, then a larger amount of memories than hitherto assumed may have been lost as children grow older and eventually become adults.

However, this suggestion calls for an explanation regarding the possible fate of these additional memories and underlying forgetting mechanisms. In other words: Why should such memories in particular be disproportionally prone to forgetting in early childhood? There is evidence that the forgetting rate of younger children is faster than older children, even with the initial level of learning kept constant (Bauer, 2012, 2015). According to Bauer (2012, 2015) this is likely to reflect fragile memory traces early in childhood due to poorer consolidation, and reconsolidation. As suggested by Berntsen and Rubin (2012), more rapid forgetting due to less efficient reconsolidation processes in early childhood may reflect a dominance of involuntary rehearsal of past events in young children. According to Berntsen (2012), involuntary remembering is an important form of rehearsal that is likely to support

consolidation and reconsolidation of past events. However, it is also an uncontrollable and context-sensitive type of recall, driven by associative mechanisms. This type of rehearsal therefore is likely to lead to a different, and probably more fragile, type of consolidation of past events, as compared to voluntary, strategic recall. Accelerated forgetting of events during early childhood may be the result (Berntsen & Rubin, 2012).

Consequently, although young children may have more (spontaneous) memories than hitherto assumed, these memories may be especially vulnerable to forgetting as their rehearsal seems more coincidental and cue dependent, and the effects on subsequent consolidation and reconsolidation therefore more fragile. Thus, based on this reasoning, we propose that *forgetting* (the 'forgotten explanation', Hayne & Jack, 2011) may indeed be a central explanation in order to understand childhood amnesia.

In addition, the present results suggest that some environmental cues, that most adults would definitely notice (i.e., returning to a different room for a test), at times may pass more or less unnoticed by young children. In this respect the results also may lend support to the 'different lenses' explanation of childhood amnesia (e.g., Bauer, 2007), or at least be consistent with this idea. Viewed in this perspective the results provide a specific example of how a given aspect of the environment is likely to be processed differently in adults and young children respectively. This is interesting because noticing the change of rooms is not dependent on advanced knowledge of a kind that one would only attribute to adults, while at the same time acknowledging that children in this age range *are* capable of registering differences between rooms (e.g., Hayne & Imuta, 2011; Newcombe, Balcomb, Ferrara, Hansen, & Koski, 2014). In short: Whereas the children most likely were capable of noticing the difference between Room A and Room B, changing rooms at test had no impact on their inclination to retrieve and talk about memories spontaneously.

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Finally, the results from the present experiment may be interpreted to suggest how the 'different lenses' explanation of childhood amnesia (Bauer, 2007) could *interact* with the 'forgetting' explanation (Bauer, 2012, 2015; Hayne & Jack, 2011): If the processing of the distinctive cues undergo changes from childhood to adulthood as suggested above, then this aspect by *it-self* may lead to accelerated forgetting, because some of the cues may have their 'cuing potential' reduced as the child grows older. However, we acknowledge that this suggestion is indeed speculative. Further research on which cues remain effective as the child matures and which will not, will be needed to pursue this hypothesis.

To conclude, we have provided further evidence that spontaneous memories can indeed be induced in young children in an experimental setting. In addition, we have provided evidence that changing the spatial context for retrieval – at least as operationalized in the present study – does not diminish the children's ability to retrieve memories spontaneously in young children. However, additional experiments using a more radical change of the retrieval context are warranted before a firm conclusion regarding to what extent the context for retrieval affects spontaneous recall can be drawn. Taken together, the results obtained here and in previous work using the same paradigm may shed new light on childhood amnesia and potential underlying mechanisms. One possible explanation that would be consistent with the present results is forgetting due to a dominance of incidental and associative rehearsal of past events in young children.

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Appendix A

Word List in alphabetical order for each of the two conditions as well as an 'Unspecific' list of words each indicating that the child had been there before without being specific about any of the two conditions. Note that synonyms and conjugations of the words presented in the lists counted as well.

Teddy Event	**Game Event**	**Unspecific**
Alfred	Ball	'Always'
Animal	Blue	'Have been'
Button	Bowling	'Again'
Clap	Bucket	'Last time'
Dog	Game	'New/other room/place'
Elephant	Green	'Same/other boxes
Elly	Hit	'Moved/changed'
Flip	Medal	
Hug	Pin	
Lives	Play	
Music	Prize	
Push	Red	
Sing	Roll	
Take/bring out or get	Throw	
Teddy	Turn over	
Turn on	Win	
Wiggle	Yellow	

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Table 1.

Descriptive statistics and t-tests based on the Congruent Word List measures and the Congruent Coding Scheme measures for Teddy and the Game event combined at the T_2 test.

	Same-Room Condition (n= 40)							Different-Room Condition (n= 40)							Same-Room vs. Different Room			
	Descriptives		One-sample t-tests (tested against the value *x*)					Descriptives		One-sample t-tests (tested against the value *x*)					Independent samples t-test			
Measure	*M*	*SD*	*x*	*t*	*df*	*p*	*r*	*M*	*SD*	*x*	*t*	*df*	*p*	*r*	*t*	*df*	*p*	*r*
Word List	1.15	1.72	.05	3.79	39	=.001	0.51	0.73	1.20	0	3.83	39	<.001	0.52	1.28	78	= .203	0.14
Coding Scheme																		
Language	0.70	0.94	.05	4.38	39	<.001	0.57	0.58	0.81	0	4.47	39	<.001	0.58	0.64	78	= .526	0.07
Gesture	0.45	0.60	0	4.77	39	<.001	0.61	0.38	0.57	0	4.05	39	<.001	0.54	0.57	78	= .572	0.06
Reliving	0.70	0.94	.05	4.38	39	<.001	0.57	0.55	0.78	0	4.44	39	<.001	0.58	0.78	78	= .440	0.09
Action	0.23	0.53	0	2.68	39	= .011	0.39	0.18	0.39	0	2.88	39	= .006	0.42	0.48	78	= .631	0.05
Object	0.28	0.55	0	3.14	39	= .003	0.45	0.15	0.43	0	2.22	39	= .032	0.34	1.13	78	= .262	0.12
Spatial	0.48	0.60	.03	4.70	39	<.001	0.60	0.40	0.63	0	4.00	30	<.001	0.54	0.55	78	= .588	0.06
Social	0.03	0.16	0	1.00	30	= .323	0.16	0.23	0.58	0	2.47	39	<.018	0.38	-2.12	78	= .038	0.23

Note: The Congruent hits are based on the condition specific hits (e.g., "teddy", "elephant") as well as condition unspecific hits (e.g., "last time", "again"). Note further that some of the variables obtained in the Same-Room Condition are not tested against "0" in the One-sample t-tests. The reason is that for these variables, the single false positive scores during baseline originating from the one boy who coincidentally talked about the Teddy event.

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Table 2.

Descriptives and binominal statistics from the results from for the control questions asked (did the child know the contents of the boxes?) at T_2

		N	Correct replies regarding known box			Correct replies regarding unknown box		
Condition	Box asked about first?	Known/ Unknown	Count	%	*p**	Count	%	*p**
Same-Room	Known	20	14	70	*p*=.115	12	60	*p*=.503
	Unknown	20	16	80	*p*=.012	8	40	*p*=.503
	(Both boxes)	40	30	75	*p*=.002	20	50	*p*=1.00
Different-Room	Known	16	15	94	*p*=.001	4	25	*p*=.077
	Unknown	24	18	75	*p*=.023	10	42	*p*=.541
	(Both boxes)	40	33	83	*p*<.001	14	35	*p*=.081
Both conditions	Known	36	29	81	*p*<.001	16	44	*p*=.618
	Unknown	44	34	73	*p*<.001	18	41	*p*=.291
	(Both boxes)	80	63	79	*p*<.001	34	43	*p*=.219

** Binomial test, test-value: p = .50 (two-tailed).*

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Figure 1. Design

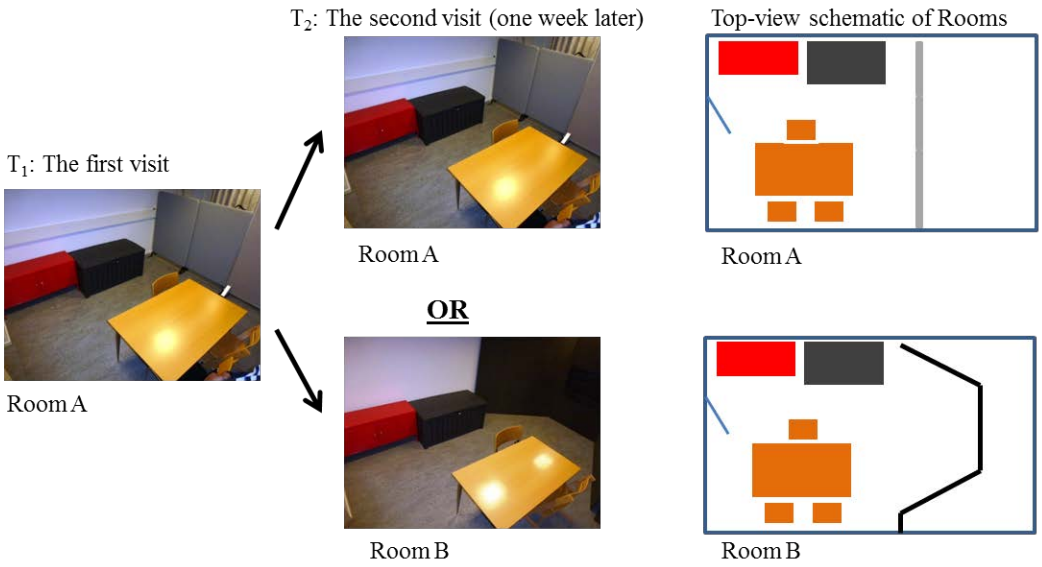

Figure Caption:
Figure 1 displays the basic design in which the children in the Same-Room Condition (n=40) returned to Room A for testing, whereas the children in the Different-Room Condition (n=40) returned to the Room B for testing. The rooms were of the same size, and were similar with respect to the arrangement of the boxes containing the two events, whereas the rooms differed with respect to location in the building as well additional furnishing.