Hearing “quack” and remembering a duck: Evidence for fluency attribution in young children

# **Abstract**

Previous research has suggested that fluency does not influence memory decisions until age 7-8. In two experiments (n=96 and n=64, respectively), children, aged 4, 6, and 8 years (Experiment 1-2), and adults (Experiment 2) studied a list of pictures. Participants completed a recognition test during which each study item was preceded by a sound providing either a highly predictive or mildly predictive context in order to make some test items more conceptually fluent. Overall, highly predictive items were recognized at a higher rate than mildly predictive items demonstrating an earlier development of the fluency heuristic than previously observed. The study provides insight on how children develop metacognitive expectations and when they start to use them to guide their memory responses.

# *Keywords:* Fluency heuristic; Conceptual priming; Recognition memory; Decision-making; Children

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**Evidence for fluency attribution in young children**

Fluency is typically defined as the speed and ease with which a stimulus is processed perceptually, conceptually or at other levels of cognitive operation (such as the lexical or motor; Topolinsky, 2013). In adults, the feeling of fluency associated with this ease of processing has been demonstrated to be related to a variety of judgements and decisions (for a review, see Alter & Oppenheimer, 2009). In memory tasks, for example, a plethora of studies have established that the feeling of fluency is usually attributed to prior exposure, resulting in a sense of past experience, which leads people to produce a higher rate of “yes” responses for fluent (easily processed) stimuli when compared to less fluent stimuli on a recognition test (e.g., Jacoby & Dallas, 1981; Jacoby & Whitehouse, 1989; Whittlesea, 1993), which is consistent with the typical effect of previous exposure on later recognition memory. Items that have been previously encountered *are* more fluently processed so this is a reliable memory cue.

From a developmental perspective, however, the association of processing fluency with prior exposure and, in consequence, the use of fluency as a guide for memory judgements (i.e., fluency heuristic) does not appear to be developed before the age of 7-8 years old (Drummey & Newcombe, 1995; Guttentag & Dunn, 2003; Lie & Newcombe, 1999; for a review, see Miller & Lloyd, 2011). For instance, Guttentag and Dunn (2003) demonstrated that when items of a recognition test are presented as a series of increasingly complete fragments, 8-year-old children, but not 4-year-old children, increased their rate of “yes” responses to stimuli identified at a faster rate. That is, more fluently completed items (whether previously seen or not) are more likely to be recognized only for older children. This finding is unexpected for two reasons. First, there is already ample evidence for a facilitated processing of previously presented information (i.e., priming effect) in children as young as 3 years old (e.g., Cycowicz, Friedman, Snodgrass, & Rothstein, 2000; Parkin & Streete, 1988). That is, the items *are* being processed more fluently but this is not being used as a cue for memory decisions (no use of the fluency heuristic). Second, these results are surprising given that 4-year-old children have recently been shown to rely on the subjective feeling of ease to assess the quality of their memory through various sorts of metamemory judgements including judgments of learning (Geurten, Willems, & Meulemans, 2015b) and confidence judgments (Hembacher & Ghetti, 2014). In addition, these children have also demonstrated use of other phenomenological experiences as memory cues such as the amount of vivid details they expect to retrieve for a specific memory (Geurten, Willems, & Meulemans, 2015a).

One potential reason for the seemingly later developmental onset of fluency heuristic use than when priming is demonstrated is that the ease of processing in prior research was focused at a perceptual as opposed to a conceptual level. In contrast, the present study investigates the effect of *conceptual* priming on children’s decision-making processes. From a developmental perspective, this could provide important information about the type of fluency that is used by children when making memory decisions across ages.

In two experiments, we examined fluency-based recognition decisions in children whose age ranged from 4 to 8. To this end, a priming procedure was employed to artificially enhance *conceptual* fluency of both study words and distractors. Specifically, the method of priming was inspired by that developed by Whittlesea and Williams (2001), which involved presenting a sentence that provides either a predictive context (e.g., “The stormy sea rocked the BOAT”) or a more neutral context (e.g., “He saved up his money to buy a BOAT”) for the final word on which the recognition judgment is made. In experiments using this procedure, words that followed predictive stems, whether targets or distractors, are more likely to be classified as studied on the recognition test compared to words that complete neutral stems (Kurilla & Westerman, 2008; Lanska, Olds, & Westerman, 2014; Miller, Lloyd, & Westerman, 2008; Westerman, 2008; Whittlesea & Williams, 2001).

Conceptual priming is theorized to depend on the richness of the knowledge database, which dramatically improves with age (Mecklenbräuker, Hupbach, & Wippich, 2003; Sauzéon, Déjos, Lestage, Arvind Pala, & N'Kaoua, 2011). To our knowledge, conceptual priming has never been used to assess the effect of processing fluency on recognition judgements in early childhood. However, the fact that young children have a poorer conceptual network than older children does not necessary mean that conceptual fluency manipulations are inappropriate. As Mecklenbräuker et al. (2003) revealed, children of different ages show similar amounts of priming when the underlying knowledge base is stable: namely, when conceptual knowledge relevant for a given priming task does not increase with age (see also Murphy, McKone, & Slee, 2003). To date, however, this hypothesis has only been tested in school-aged children.

In order to explore whether children will attribute conceptual fluency to recognition memory decisions, three groups of participants aged 4, 6, and 8 (Experiments 1 and 2) and a group of adults (Experiment 2) were given a list of pictures depicting objects and animals to study. During the recognition test, each stimulus (e.g., the picture of a duck) was preceded by a prime taking the form of a degraded sound which was either conceptually predictive of the subsequent item (e.g., quacking) or which only provided distantly related context for it (e.g., cackling). Furthermore, as fluency resulting from predictive context does not seem to be used when it predicts the appearance of the subsequent stimuli without any surprise (Whittlesea & Leboe, 2003; Whittlesea & Williams, 1998, 2000, 2001), we deteriorated the primes. We expected the sudden onset of a test stimulus after the presentation of a predictive prime to induce a feeling of fluency (Topolinsky & Reber, 2010). In turn, we anticipated this enhanced fluency to prompt at least the older children to give more positive recognition responses for fluent items (highly predictive) compared to less fluent items (mildly predictive). This pattern of results would demonstrate both (a) the utility of an age-adapted conceptual priming procedure to induce fluency and (b) the use of processing fluency as a cue for recognition decisions. Theoretically, this research could provide additional evidence for the question of whether memory develops across childhood through the improvement of cognitive and metacognitive processes associated with retrieval (e.g., Newcombe, Lloyd, & Ratliff, 2007) and/or through the improvement of the conceptual knowledge database (e.g., Rovee-Collier, 1999).

# **Experiment 1**

**Method**

**Participants.** The final sample included 96 typically developing children aged 4 (*n* = 32; 20 females; mean age = 54.07 months; SD = 3.21), 6 (*n* = 32; 17 females; mean age = 76.87 months; SD = 3.69), and 8 (*n* = 32; 16 females; mean age = 99.84 months; SD = 3.81) years. Of these participants, 91 children were Caucasian, 5 children were originally from Maghreb. The native language of all children was French and they all were from homes of a middle- to upper-class socioeconomic status. Four additional participants were tested but excluded from the final analyses because they responded “no” to all items during the recognition test. No group difference was found in terms of parental education level and non-verbal intelligence, *Fs* < 2, respectively assessed using both parents’ years of education and scores on the Matrix Reasoning test (Wechsler, 2004, 2005). The sample was recruited from kindergartens and elementary schools in Belgium.

**Materials.** The stimuli consisted of 48 two-dimensional colored line drawings (objects and animals) extracted from the standardized data set developed by Rossion and Pourtois (2004) and selected to be easily identified by 4-years-old children. On average, the pictures contained similar amounts of detail.

Ninety-six sounds were created so that each picture stimulus (e.g., duck) was associated with both a highly (e.g., quacking) and a mildly (e.g., cackling) predictive sound. (For details on the stimuli creation, see supplemental methods and results section). An additional set of 5 consistently identified sounds were selected for calibrating each participant’s prime duration.

**Procedure.** Written consent was obtained from the parents before the study started. Children were tested individually in a quiet room in their school, and underwent a 45-minute session including a study and a recognition phase. For a visual depiction of the procedure, see Figure 1. These two phases were separated from each other by a 15-minute delay that was filled with verbal and non-verbal cognitive tasks as well as with a sound identification task (calibration phase). The participants wore headphones during both the calibration and the recognition phase.

*Study phase.* A list of 24 pictures was presented in a random order to each child. Each stimulus appeared at the center of the screen for 3 s before being followed by a blank screen for 500 ms. Participants were instructed to study the items as carefully as possible in preparation for an upcoming test of an unspecified nature.

*Calibration phase.* During the 15-minute interval that preceded the recognition test, participants were given an identification task during which 5 clear sounds were presented one by one in the headphones. Children was instructed to say aloud as quickly as possible which object or animal makes the sound they have just heard. The experimenter pressed the response key to stop the timer when children started to speak, then pressed another response key to confirm that the provided answer was correct. The estimated reaction time of the experimenter (250 ms) substracted from the shortest time made by each child to correctly identify a sound was used to determine the duration of the prime in the recognition phase. Furthermore, three verbal and non-verbal cognitive tasks were also administered during the 15-minute delay in order to generate cognitive interference (for more details about these tasks, see supplemental methods section).

*Recognition phase.* Children were told that they would be presented with both studied and non-studied items, and that they had to respond “yes” if they remembered seeing the stimulus in the first phase, and “no” if they did not. Participants were also informed that they would hear noise before the appearance of each stimulus. They were told that the noise aimed at distracting them and so were instructed not to pay attention to it. The recognition test contained 48 pictures, including 24 studied items (targets) and 24 unrelated distractors that were displayed at the center of the screen in random order. Target items and distractors were counterbalanced so that an equal number of participants saw each test stimulus as a target and as a distractor. Every picture was preceded by the presentation of either a highly predictive or mildly predictive prime. The duration of the prime was specific to each child and determined through the calibration phase so that, during the recognition test, each prime would be suddenly stopped prior to its explicit identification by the participant. The prime was either highly predictive of the upcoming test picture (e.g., quacking – duck) or consistent with the test picture, but poorly predictive of it (e.g., cackling – duck). Half of the test items (either targets or distractors) were preceded by a highly predictive sound. The pictures were counterbalanced through the highly predictive and the mildly predictive conditions so that each picture was in the highly predictive condition for an equal number of participants. The test stimulus appeared directly after the end of the sound prime. After each response, a blank screen was presented for 250 ms, followed by the presentation of the next prime.

**Results and Discussion**

**Data analyses.** The primary goal of this study was to determine whether young children are more likely to judge fluent stimuli as being “studied” on a recognition test, indicating that they can use ease of processing as a cue for their recognition decisions. A 3 (Age Group: 4-, 6-, and 8-year-old) x 2 (Type of Prime: Highly Predictive or Mildly Predictive) x 2 (Status of Test Item: Target or Distractor) mixed-factor design was conducted on the proportion of “yes” responses. As previous studies demonstrated developmental differences in young children’s recognition performance for targets and distractors (Lloyd, Doydum, & Newcombe, 2009), we chose to examine the effect of this factor in our analyses. Table 1 displays the proportion of “yes” responses for each age group depending on the item status and the type of prime. A priming effect was also estimated for each age group and for each item status by subtracting the proportion of “yes” responses for the fluent stimuli (highly predictive) from the proportion of “yes” responses for the less fluent stimuli (mildly predictive). A positive priming effect indicated use of the fluency heuristic. Furthermore, we also examined whether the duration of the prime presentation influenced the extent to which children rely on the fluency heuristic to guide their memory decisions.

The significance level was set at .05. Preliminary analyses indicated homogeneity of variance between the age groups and revealed no gender or order effect on any of the dependent variables. Moreover, none of the participants reported noting anything special about the test or the noise, suggesting that our experimental manipulation was not detected.

**Prime duration.** We first investigated whether the duration of the prime differed between age groups. The results of the one-way ANOVA revealed no main effect of age, *F* < 1, demonstrating that children of the three age groups identified the sound at the same speed (mean = 2.45, 2.48, and 2.18 seconds for 4-, 6-, and 8-year-old children, respectively) and, thus, were exposed to the conceptual prime for the same length of time (for more analyses on the prime duration effect, see supplemental results section).

**Recognition performance.** The results of the mixed analysis of variance (ANOVA) on “yes” responses revealed no main effect of age, *F<1*. Typical of recognition memory experiments, there was a main effect of status of the test item with targets being recognized at a higher rate (*M*=.90) than distractors (*M*=.17), *F*(1, 93)=688.25, *p*<.001, *ηp2*=.88. Critically, there was also a main effect of prediction. Highly predictive items were recognized more often (*M=*.55) than mildly predictive items (*M*=.53), *F*(1, 93)=4.65, *p*<.03, *ηp2*=.05. No two way interactions were significant*,* all *p’s*>.30. The three way interaction approached significance, *F*(2, 93)=2.59, *p*<.08. As may be noted in Table 1, this is due to a shift in priming effects as a function of age. Four-year-olds showed more priming effects for targets than distractors and this trend was reversed in the oldest children.

On the whole, these results reveal that the three groups of children included in our sample demonstrate a higher rate of positive recognition responses for fluent stimuli, indicating the use of the fluency heuristic. However, the fluency effect in the present study was smaller than that in other fluency illusion work. The high accuracy level and the absence of age effect on recognition performance suggest that a ceiling effect could account for this small effect. As demonstrated by Gallo, Perlmutter, Moore, and Schacter (2008), the fluency illusion is reduced when people are able to recall episodic details about the to-be-judged stimulus (see also Westerman, 2001). It is likely that larger fluency effects would be observed if recognition memory performance was less accurate. To test this idea, we chose to conduct a second experiment using the same procedure, but with a substantial reduction of the encoding time in order to decrease the participants’ level of accuracy and potentially increase the fluency effect. Furthermore, in addition to the three groups of children, a group of adults was also included in Experiment 2 to examine whether older children are approaching a mature use of the fluency heuristic.

# **Experiment 2**

**Method**

**Participants.** The sample included 48 typically developing children aged 4 (*n* = 16; 7 females; mean age = 4.81 months; SD = 0.38), 6 (*n* = 16; 10 females; mean age = 6.32 years; SD = 0.23), and 8 (*n* = 16; 8 females; mean age = 8.64 months; SD = 0.57) years and 16 adults (10 females; mean age = 27.53 years; SD = 5.38). All of these participants were Caucasian and from homes of a middle- to upper-class socioeconomic status. Their native language was French.

**Materials and Procedure.** The materials and procedure employed in Experiment 2 were identical to Experiment 1 with two exceptions: (a) the encoding time was reduced to 750 ms with a blank screen ISI of 250 ms and (b) 12 filler (untested) pictures were included at study. The goal of these manipulations was to decrease accuracy during the recognition test.

**Results and Discussion**

**Prime duration.** Matching Experiment 1, the results of the one-way ANOVA revealed no main effect of age, *F*<0.75, demonstrating that participants of the four age groups were exposed to the conceptual prime for the same length of time (mean= 2.50, 2.17, 2.63, and 2.08 seconds for 4-, 6-, 8-year-olds and adults, respectively).

**Recognition performance.** The results of the mixed analysis of variance (ANOVA) on “yes” responses revealed a main effect of item status with targets being recognized at a higher rate (*M*=.74) than distractors (*M*=.27), *F*(1, 60)=383.42, *p*<.001, *ηp2*=.86. Again, there was also a main effect of the type of prime. Highly predictive items were recognized more often (*M=*.56) than mildly predictive items (*M*=.45), *F*(1, 60)=39.01, *p*<.001, *ηp2*=.39. A age x status interaction was also found, *F*(1, 60)=9.09, *p*<.001, *ηp2*=.31, indicating that 4- and 6-year-old children produced a lower level of “yes” responses for targets (*M*=.65-.71) and a higher level of “yes” responses for distractors (*M*=.36-.25) than older children and adults (*M*=.77-.85 and .26-.21, for targets and distractors, respectively). Critically, the three way interaction was significant, *F*(2, 60)=10.80, *p*<.001,*ηp2*=35. Specifically, linear contrast analyses carried out for each age group revealed that older children and adults show more priming effects for distractors than for targets, *ps*<.03, while the pattern was reversed in the two youngest groups, *ps*<.03 (Table 1). No other main or interaction effect reached significance, Fs<1.

Overall, these findings replicated those obtained in Experiment 1, indicating that even young children can use fluency as a heuristic to guide their memory decisions. Further, a larger priming effect was obtained when compared with Experiment1. This seems to confirm the hypothesis of Gallo et al. (2008) that fluency use decreased with the quality of the encoding. Moreover, our results also reveal that older children and adults do not use fluency like younger children do, suggesting a developmental change in the use of the fluency heuristic despite it being applied from age 4 onward.

# **General Discussion**

The main goal of the present study was to investigate children’s use of fluency as a heuristic in recognition judgements when fluency was manipulated through conceptual priming. For this purpose, two experiments were conducted where a highly or a mildly predictive prime was presented to participants before the appearance of each recognition test item. The results revealed that, like adults, children – whatever their age – demonstrate a higher rate of recognition for more fluent stimuli than for less fluent stimuli, demonstrating reliance on the fluency heuristic to guide memory decisions.

This finding is of importance for two primary reasons. First, the fact that our priming manipulation was successful demonstrates, for the first time, that, when an appropriate procedure is used, ease of conceptual processing can be enhanced by exposing participants to concepts semantically related to the test stimuli. Our results indicated that children were sensitive to conceptual priming to a similar extent, supporting the hypothesis of Mecklenbräuker et al. (2003) according to which an increased semantic knowledge base accounts for age-related improvements in conceptual implicit memory tests (see also Murphy et al., 2003; Sauzéon et al., 2011). Our experimental paradigm has the advantage of being non-verbal in nature and appropriate for young participants. Most previous research on conceptual fluency has relied on methods involving reading, which are highly unsuitable for young children (e.g., Miller et al., 2008; Whittlesea & Williams, 2001).

Second, our findings also indicate that the reliance on the fluency heuristic may develop much earlier in childhood than previously hypothesized. In the present experiment, 4-years-old children were as likely as older children to show a fluency effect. Furthermore, statistical analyses also reveal that 8-year-olds and adults show more priming effects for distractors than for targets while this pattern is reversed in the youngest children. On the contrary, it appears that when better memory cues are available (i.e., presence of episodic details for targets), older participants rely less on the fluency rule to guide their decisions. However, they use it more intensively when no other cue is available (i.e., absence of episodic details for distractors). There are at least two possible explanations for these results. First, it is possible that older participants rely more on episodic cues than younger participants because more episodic details are available to them due to their better memory abilities. The second explanation, not incompatible with the former, could be that younger participants base their judgment on a direct assessment of absolute fluency (i.e., more fluently processed items are more likely to be called studied regardless of the retrieval of episodic details), while older participants only rely on fluency when it is higher than what is expected in a given context (i.e., when fluency occurs without the retrieval of episodic details). Interestingly, the latter pattern has been suggested as a probable developmental trend that warrants future research (Miller & Lloyd, 2011). It is also consistent with a perspective of memory development that focuses on change over stability (e.g., Newcombe et al., 2007). Specifically, our results seem to indicate that one of the possible explanations accounting for changes in memory across early childhood could involve an evolution in the way metacognitive cues (e.g., fluency) are used by children to regulate their memory decisions. However, this assumption is only based on the analysis of inter-individual differences. To confirm this, the influence of fluency on children’s memory decisions should, of course, be investigated by examining intra-individual changes over time. Similarly, future studies should be conducted to determine the relative contribution of cognitive and metacognitive processes to these developmental changes.

From a theoretical point of view, the finding that 4- and 6-years-old children use subjective experience of fluency as a cue to memory appears to be in contradiction with previous research focusing on the influence of fluency on young children’s recognition decisions (e.g., Drummey & Newcombe, 1995; Guttentag & Dunn, 2003). Indeed, these studies generally demonstrate no use of the fluency heuristic before the age of 7-8 years old. However, several methodological differences could possibly account for these divergent findings. First, the priming paradigms employed in these previous studies required perceptual identification capacities which are sometimes shown to improve with age (e.g., Cycowicz et al., 2000; Guttentag & Dunn, 2003). For instance, Guttentag and Dunn found that 8-years-old children identified fragmented pictures in fewer steps than did 4-years-old children. If the identification task was difficult for young children, it is possible that all items were perceived as globally disfluent and that differences in subjective ease of processing between the stimuli were too slight to be detected by young children. Second, the difference observed between the results of the present and previous studies could result from the fact that fluency is enhanced through *conceptual* priming in our experiment while the other research focused on *perceptual* priming. It is possible that conceptual priming procedure simply produces more artificial fluency than perceptual priming procedure in children. However, because perceptual priming is already shown to facilitate the processing of stimuli in 3-years-old children (e.g., Cycowicz et al., 2000), future research should be carried out to investigate the latter hypothesis and test the effect of both perceptual and conceptual priming on young children’s recognition memory. To this end, a procedure manipulating perceptual processing regardless of children’s perceptual identification abilities should be used.

The findings of the present experiment are also coherent with other studies which have recently established that the implementation of inference rules, based on subjective experience or metacognitive expectations, can be involved in various sorts of decision-making processes in early childhood (Geurten et al., 2015a; Geurten et al., 2015b; Hembacher & Ghetti, 2014). For example, preschoolers are shown to base their judgements of learning (JoLs) on the phenomenological experience of ease of encoding (Geurten et al., 2015b). Similarly, recognition decisions of 4-years-old children are demonstrated to be influenced by metacognitive expectations about the type of information that should be accessible to memory in a given context (Geurten et al., 2015a). On the whole, these findings seem to indicate that children can use metacognitive associations to regulate their memory decisions very early in childhood.

In sum, conceptual processing fluency can already be attributed to prior experience by 4-year-old children, demonstrating early application of the fluency heuristic. Further investigations are needed to confirm these findings and further explore the development of the fluency heuristic in children. For example, studies examining when children learn to discount fluency in inappropriate contexts should be carried out. As Miller and Lloyd (2011) pointed out, fluency is not always a reliable cue to memory. Additional exploration of the developmental trajectory of the fluency heuristic would provide important information on how people develop complex metacognitive expectations that guide their memory responses. With regard to this aim, the present study not only provides a first and crucial step toward a better understanding of the development of the fluency heuristic in children, but also demonstrates the efficacy of a new conceptual priming procedure, independent from reading skills and extensive semantic memory development.

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**Appendix**

*Examples of Stimuli and Associated Primes*

|  |  |  |
| --- | --- | --- |
| Picture stimuli | Highly predictive sounds | Mildly predictive sounds |
| Duck | Quacking | Cackling |
| Dog | Barking | Growling |
| Cat | Meowing | Purring |
| Phone | Phone ring | Vibrate mode |
| Train | Train ride | Horn noise |
| Gun | Shot | Cylinder noise |

Table 1

*Mean Proportion of “yes” Responses as a Function of the Status of the Items (Target vs. Distractor) and the Type of Prime (Highly Predictive vs. Mildly Predictive) in Experiment 1 and 2*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Target | | | Distractor | | | **Total** | | |
|  | High | *Mild* | *PE* | High | *Mild* | *PE* | *High* | *Mild* | *PE* |
| Experiment 1 |  |  |  |  |  |  |  |  |  |
| 4-year olds | .92 | .88 | .04 | .22 | .20 | .02 | .57 | .54 | .03 |
| 6-year olds | .94 | .91 | .03 | .19 | .15 | .04 | .57 | .53 | .04 |
| 8-year olds | .86 | .89 | -.03 | .16 | .13 | .03 | .51 | .51 | .00 |
|  |  |  |  |  |  |  |  |  |  |
| Experiment 2 |  |  |  |  |  |  |  |  |  |
| 4-year-olds | .76 | .54 | .22 | .36 | .35 | .01 | .56 | .44 | .12 |
| 6-year-olds | .79 | .62 | .17 | .28 | .23 | .05 | .53 | .42 | .11 |
| 8-year-olds | .76 | .78 | -.02 | .33 | .18 | .15 | .54 | .48 | .06 |
| Adults | .88 | .82 | .06 | .30 | .11 | .19 | .59 | .47 | .12 |

Notes: High=highly predictive, Mild=mildly predictive, PE=priming effect, Standard Errors ranged from .02-.06 in both experiments.

**Figure Caption**

**Figure 1.** Description of the experimental procedure.

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