Supporting Information

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SI Text

Accuracy by Trial Type. As in work with adults (1), there was no interaction between age and the BX and AY nontarget trial types in terms of accuracy [$F(1,55) = 1.99$, $P = 0.16$]. Children sometimes corrected their responses mid-trial, which could make reaction time (RT) and conditionalized accuracy measures more sensitive indicators of context effects than simple accuracy.

Note that the context processing indexed by AY and BX trials is dissociable from that of simple rule following, even when BY accuracy is taken into account. Controlling for the overall accuracy difference between groups (as the main effect of age in a 3-level repeated measures ANOVA), BY trial accuracy improves less with age than accuracy on the AY and BX trials that are indicative of context processing [$F(1,55) = 6.33$, $P < 0.02$]. In other words, AY and BX accuracy show effects which are dissociable from the relatively smaller age-related improvement in simple rule-following.

Accuracy Conditionalized on Response Speed. In addition to analyses of raw accuracy, proactive control can be assessed by examination of error rates in the different trial types, conditionalized on whether RTs are fast or slow (2). Specifically, proactive control is characterized by relatively more AY errors when RTs are fast (indicative of anticipation), but more BX errors when RTs are slow (indicative of poor anticipation; ref. 3). Eight-year-olds showed this adult pattern (Fig. S1*a*), with more AY errors on fast than slow trials [$t(33) = 2.4$, $P = 0.02$], fewer BX errors on fast than slow trials [$t(33) = 2.19$, $P < 0.04$], and a significant crossover interaction between RT and trial type [$F(1,33) = 11.68$, $P < 0.01$]. In contrast, 3.5-year-olds failed to show these patterns (all P's > 0.2), resulting in a three-way interaction between age, trial type, and RT [$F(1,55) = 4.37$, $P = 0.04$, with a Tukey power transform correcting for heteroscedasticity], thus demonstrating a transition to more proactive mechanisms with age.

Accuracy Conditionalized on Trial Sequence. Because local as well as the global frequency of AX trials may affect nontarget trial performance, we analyzed AY and BX trial accuracy separately for trials that were preceded by one, two, or three target AX trials (Fig. S1*b*). To examine the linear trends across all three levels of "AX" frequency, we first derived a slope for each subject relating their performance to the number of preceding AX trials. Next, we used t tests to compare these slopes across age groups and thereby examine shifts in control strategy. This analysis controls for baseline differences in errors between groups (these would be captured by the intercept rather than the slope).

Given that proactive maintenance of the "A" cue causes an expectation of an "X," increasingly frequent AX trials may increase the tendency to err on AY trials; conversely, reactive control may decrease the tendency to err, because the "Y" is increasingly salient after more "X" probes.* Indeed, 8-year-olds and 3.5-year-olds showed an interaction that may reflect a reactive-to-proactive shift, in terms of group differences in the slopes relating AY performance to local AX frequency [$t(53) = 2.44$, $P = 0.04$].

The same logic applies in reverse for BX trials. In this case, the B cue is more salient with more preceding AX trials; those using proactive control may be more likely to update this stimulus context, leading to better BX performance. Conversely, increasingly frequent AX trials may more strongly interfere with retrieval of the B context during X probes, as required under a reactive regime. Consistent with these predictions, 8-year-olds and 3.5-year-olds again showed patterns that may reflect proactive and reactive control, in terms of group differences relating BX performance to the local frequency of AX trials [$t(52) = 2.26$, $P = 0.03$]. Finally, the reactive-to-proactive shift and the opposing effects of local AX frequency on both BX and AY performance was confirmed by the predicted crossover interaction between age, the slope of performance across frequencies of "AX" trials, and nontarget trial type [$F(1,50) = 20.13$, $P < 0.01$].

An alternative test of the simple effects in this interaction is paired t-tests across trial types within each age-group. This approach confirmed the prediction within the 3.5-year-old group [increased BX and decreased AY errors with more preceding X trials; $t(18) = 3.52$, $P < 0.01$], but was not significant within the older group (although it trended in the predicted direction; $P = 0.13$).

Context Processing Indices. A d'_{context} was calculated on the basis of AX hits and BX false alarms (2). This measure reflects sensitivity to preceding context regardless of whether the responsible mechanism is reactively or proactively engaged. The d'_{context} was significantly greater than zero overall [$t(56) = 16.79$, $P < 0.01$, $M = 2.63$, SD $= 1.18$] and for each group individually [8-year-olds: $t(33) = 29.84$, $P < 0.01$, $M = 3.38$, SD $= .66$; 3.5-year-olds: $t(22) = 8.28$, $P < 0.01$, $M = 1.53$, SD $= .89$], and increased with age [$t(55) = 9.01$, $P < 0.01$], mirroring the opposite transition previously observed among young and elderly adults (1).

Similarly, AY and BX RTs were directly compared to index proactive context processing (whereby proactive control should benefit BX but hurt AY trials; ref. 2). This context processing index of proactive control revealed that 8-year-olds showed significantly more proactive control than 3.5-year-olds [$F(1,50) = 7.78$, $P < 0.01$].

As illustrated in Fig. 2 in the main text, the relative workload during the delay period is most sensitive to differences between the age-groups because the environment least supports effortful context processing during this time. However, individual differences in overt performance are better predicted by workload during the probe period, perhaps because this is the time when responses are provided.

1. Paxton JL, Barch DM, Racine CA, Braver TS (2008) Cognitive control, goal maintenance, and prefrontal function in healthy aging. *Cereb Cortex* 18:1010–1028.
2. Braver TS, Barch DM, Cohen JD (1999) Mechanisms of cognitive control: Active memory, inhibition, and the prefrontal cortex (Carnegie Mellon Univ., Pittsburgh, PA), Technical Report PDP-CNS-99–1.
3. Gathercole SE (1998) The development of memory. *J Child Psychol Psychiatry* 39:3–27.

*We thank an anonymous reviewer for pointing out that reactive children might be expected to show *increased* errors on Y trials after more X probes, if they ''eased into'' expecting only X's. However, children appear sufficiently engaged with the probes to resist such perseveration and instead demonstrate this more interesting pattern.

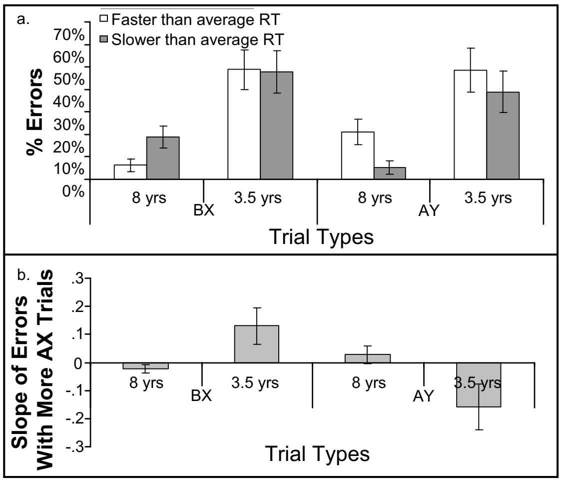

Fig. S1. Conditionalized accuracy. (*a*) Only 8-year-olds show the profile predicted for proactive control: significantly increased errors on slow trials (gray bars) relative to fast (white bars) BX trials, and significantly decreased errors on slow relative to fast AY trials. (*b*) Relative to 8-year-olds, 3.5-year-olds show significant increases in BX errors as a function of the number of preceding AX trials, consistent with the use of reactive mechanisms which are susceptible to retrieval-based interference; likewise, relative to 8-year-olds, 3.5-year-olds also show significantly fewer AY errors as a function of the number of the number of preceding AX trials, consistent with the increased salience of Y probes under a reactive regime.