Supplementary Information

RW model with a lower learning rate from Zhang et al., 2018

Using a lower learning rate that was derived from infants' pupillometry study (0.075), we found similar results to the results that are presented in the main manuscript.

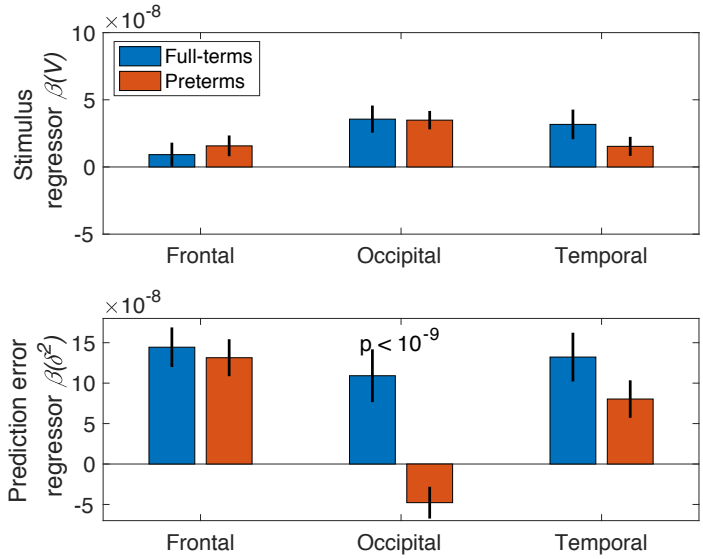

Figure S1. Response for the presentation of a visual stimulus (stimulus-evoked; V) and Response to prediction error (δ^2) in RW model with a lower learning rates (0.055). In full-term infants, all three lobes responded to prediction error. In preterm infants, the response to prediction error was limited to the Frontal and Temporal lobes. These findings suggest that top-down connections from Frontal to Occipital are impaired in preterm infants, and, when intact, communicate prediction error. See Table S1 for statistics. Relates to the main text and serves as an alternative approach to Figure 2.

Lobe	Effect	F	DF2	p
Frontal	Group X V	0.5	1080.9	0.4
	Group X δ^2	0.02	1074.2	0.9
	(Group X V) vs. (Group X δ^2)	0.12	1134	0.7
	Full-terms' V	1.1	99.2	0.3
	Preterms' V	**4.1**	**88.8**	**<0.05**
	Full-terms' δ^2	**34.8**	**45**	**$<10^{-7}$**
	Preterms' δ^2	**33.1**	**54.7**	**$<10^{-7}$**
Occipital	Group X V	0.07	1078	0.8
	Group X δ^2	**35.6**	**1070.3**	**$<10^{-9}$**
	(Group X V) vs. (Group X δ^2)	**22.9**	**1134**	**$<10^{-6}$**
	Full-terms' V	**12.4**	**64.7**	**<0.001**
	Preterms' V	**26**	**71.3**	**$<10^{-6}$**
	Full-terms' δ^2	**11.2**	**35.6**	**<0.005**
	Preterms' δ^2	**5.9***	**57.8**	**<0.05**
Temporal	Group X V	1.9	1082.7	0.2
	Group X δ^2	3.1	1076.8	0.08
	(Group X V) vs. (Group X δ^2)	1	1134	0.3
	Full-terms' V	**8.3**	**37.3**	**<0.01**
	Preterms' V	**4.7**	**105.7**	**<0.05**
	Full-terms' δ^2	**19.3**	**35.9**	**$<10^{-5}$**
	Preterms' δ^2	**12.1**	**50.1**	**<0.005**

Table S1. Mixed-effects statistics of RW model with a lower learning rate (0.055). In each lobe, we used the mixed effect formula: response ~ V + δ^2 + Group : V + Group : δ^2 + (V + δ^2 | subject). Relates to Figure S1.

*negative response

RW model with individually fitted learning rate (α)

Using a more flexible model with individually fitted learning rate, we found similar results to the model with the pre-defined learning rate, as described in the main text (with the other parameters taken from Li et al., 2011). We did not find a group difference in the individually fitted learning rates (z = 0.8, *n.s.*; Mann-Whitney U-test)

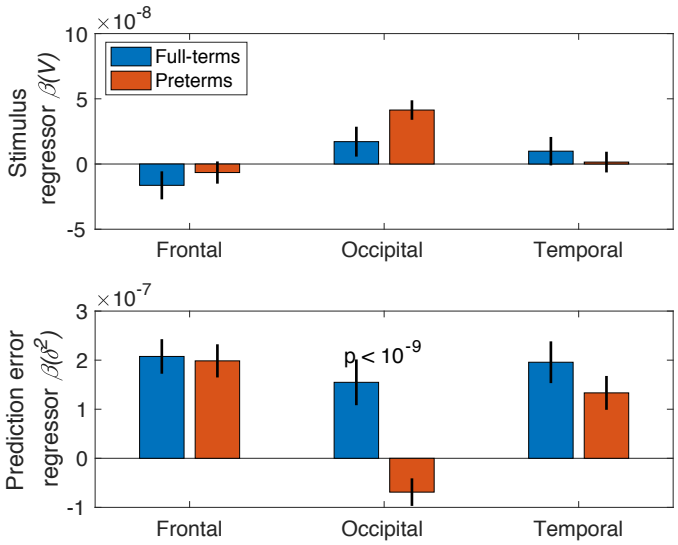

Figure S2. Response for the presentation of a visual stimulus (stimulus-evoked; V) and Response to prediction error (δ^2) in RW model with individually fitted learning rates (α). In full-term infants, all three lobes responded to prediction error. In preterm infants, the response to prediction error was limited to the Frontal and Temporal lobes. These findings suggest that top-down connections from Frontal to Occipital are impaired in preterm infants, and, when intact, communicate prediction error. See Table S2 for statistics. Relates to the main text and serves as an alternative approach to Figure 2.

Lobe	Effect	F	DF2	p
Frontal	Group X V	0.4	1096.7	0.5
	Group X δ^2	0.001	1056.3	0.97
	(Group X V) vs. (Group X δ^2)	0.04	1134	0.8
	Full-terms' V	2.3	399.6	0.1
	Preterms' V	0.6	407.5	0.4
	Full-terms' δ^2	**34.8**	**48**	**$<10^{-7}$**
	Preterms' δ^2	**34.6**	**50.6**	**$<10^{-7}$**
Occipital	Group X V	3.1	1092.4	0.08
	Group X δ^2	**33.6**	**1053.5**	**$<10^{-9}$**
	(Group X V) vs. (Group X δ^2)	**25.6**	**1134**	**$<10^{-7}$**
	Full-terms' V	2.2	411.3	0.1
	Preterms' V	**30.7**	**202.8**	**$<10^{-8}$**
	Full-terms' δ^2	**11**	**37.4**	**<0.005**
	Preterms' δ^2	**6***	**56.5**	**<0.05**
Temporal	Group X V	0.2	1098.8	0.7
	Group X δ^2	2.7	1070.9	0.1
	(Group X V) vs. (Group X δ^2)	1.4	1134	0.2
	Full-terms' V	0.8	87.2	0.4
	Preterms' V	0.03	553.1	0.9
	Full-terms' δ^2	**21.2**	**35.3**	**$<10^{-5}$**
	Preterms' δ^2	**15**	**49.7**	**<0.0005**

Table S2. Mixed-effects statistics of RW model with individually fitted learning rate (α) for response from each lobe. In each lobe, we used the mixed effect formula: response ~ V + δ^2 + Group : V + Group : δ^2 + (V + δ^2 | subject). Relates to Figure S2.
*negative response

Hybrid (RW + PH) model

Using a two-layer associative learning model, as described in (Li et al., 2011), we found similar results to the one-later associative learning model (RW), as described in the main text.

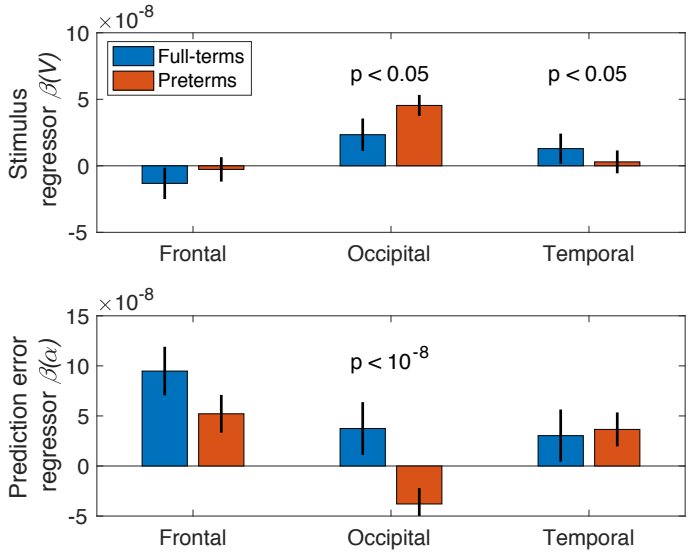

Figure S3. Response for the presentation of a visual stimulus (stimulus-evoked; V) and Response to prediction error (δ^2) in hybrid (RW+PH) model with individually fitted learning rates (α). In full-term infants, all three lobes responded to prediction error. In preterm infants, the response to prediction error was limited to the Frontal and Temporal lobes. These findings suggest that top-down connections from Frontal to Occipital are impaired in preterm infants, and, when intact, communicate prediction error. See Table S2 for statistics. Relates to the main text and serves as an alternative approach to Figure 2.

Lobe	Effect	F	DF2	p
Frontal	Group X V	0.5	1076.6	0.5
	Group X δ^2	0.04	1094.7	0.8
	(Group X V) vs. (Group X δ^2)	0.3	1135	0.6
	Full-terms' V	**9.3**	**48.8**	**<0.005**
	Preterms' V	**11.4**	**63.6**	**<0.005**
	Full-terms' δ^2	**33.2**	**72.7**	**$<10^{-6}$**
	Preterms' δ^2	**26.6**	**68.8**	**$<10^{-5}$**
Occipital	**Group X V**	**6**	**1077.1**	**<0.05**
	Group X δ^2	**34.8**	**1089.1**	**$<10^{-8}$**
	(Group X V) vs. (Group X δ^2)	**8.1**	**1135**	**<0.005**
	Full-terms' V	**19.7**	**42.3**	**$<10^{-4}$**
	Preterms' V	**14.2**	**53.5**	**<0.0005**
	Full-terms' δ^2	**12.7**	**45.6**	**<0.001**
	Preterms' δ^2	**6***	**61**	**<0.05**
Temporal	**Group X V**	**4.7**	**1083.3**	**<0.05**
	Group X δ^2	2.5	1092.7	0.1
	(Group X V) vs. (Group X δ^2)	0.03	1135	0.9
	Full-terms' V	**14.3**	**33.1**	**<0.001**
	Preterms' V	**9.6**	**81.6**	**<0.005**
	Full-terms' δ^2	**21.7**	**48.8**	**$<10^{-4}$**
	Preterms' δ^2	**12.8**	**82.2**	**<0.001**

Table S3. Mixed-effects statistics of hybrid model (RW + PH) for response from each lobe. In each lobe, we used the mixed effect formula: response ~ V + δ^2 + Group : V + Group : δ^2 + (V + δ^2 | subject). Relates to Figure S3.

*negative response

References

Li J, Schiller D, Schoenbaum G, Phelps EA, Daw ND (2011) Differential roles of human striatum and amygdala in associative learning. Nat Neurosci 14:1250–1252 Available at: http://www.ncbi.nlm.nih.gov/pubmed/21909088.

Zhang F, Jaffe-Dax S, Wilson R, Emberson L (2018) Prediction in infants and adults: A pupillometry study. Dev Sci:e12780 Available at: http://doi.wiley.com/10.1111/desc.12780.