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Regulation of Chick *Ebf1–3* Gene Expression in the Pharyngeal Arches, Cranial Sensory Ganglia and Placodes

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Abstract
This study was conducted to identify the regulation of the expression of the *cEbf1–3* (chick early B-cell factor 1–3) genes in the pharyngeal arches (PAs), cranial sensory ganglia and placodes. *cEbf1* and *cEbf3* were mainly expressed in the cranial neural crest cells (NCCs) occupying the PAs, but *cEbf2* was expressed in the mesenchymal core. *cEbf1–3* were prominently expressed in the olfactory placodes, but *cEbf1* and *cEbf3* were only expressed in the otic vesicle. *cEbf1* was expressed in all cranial sensory ganglia, *cEbf2* (only) in the dorsolateral ganglia and *cEbf3* in the trigeminal and vestibular ganglia. The removal of the source (the cranial neural tube) of the cranial NCCs before their migration to the PAs led to downregulation of *cEbf1* and *cEbf3* and upregulation of *cEbf2* expression. Gain- and loss-of-function experiments showed that sonic hedgehog did not regulate *cEbf1–3* expression in the PAs or associated ganglia. Bone morphogenetic protein 2 (Bmp2) can, however, directly and indirectly regulate *cEbf1* and *cEbf3* expression in the PAs and the proximal (NCC-derived) portion, but not the distal (placodal-derived) portion of the cranial sensory ganglia. Conversely, *cEbf2* expression was upregulated following injection of Noggin before the migration of NCCs, but did not change after the overexpression of either Noggin or Bmp2 in the arch after NCC migration. In conclusion, Bmp2 regulates *cEbf1* and *cEbf3* expression in PAs and cranial sensory ganglia both directly and indirectly, via the migration of cranial NCCs. However, *cEbf2* expression in the mesenchymal core of PAs is controlled by other undetermined signals.

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Abbreviations used in this paper

Bmp2	bone morphogenetic protein 2
cEbf	chick early B-cell factor
NCCs	neural crest cells
NT	neural tube
OV	otic vesicle
PA	pharyngeal arch
r	rhombomere
Shh	sonic hedgehog

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