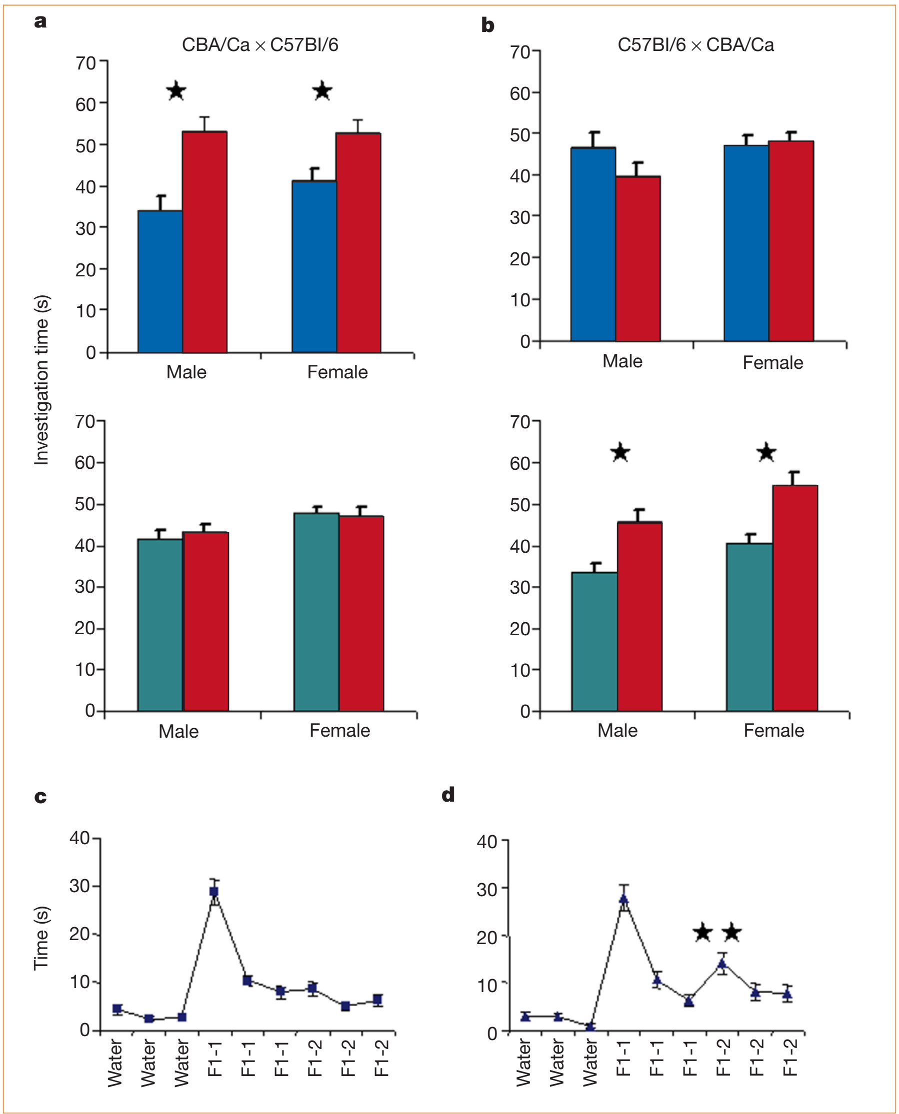

Figure 1 Odour preference of reciprocal-cross F_1 males and females for female urinary odours. Test urine from different mouse strains: blue, CBA/Ca; red, BALB/c (unrelated controls); green, C57Bl/6. **a,** (CBA/Ca × C57Bl/6) F_1 males and females show a preference for BALB/c female urine compared to CBA/Ca female urine, but no preference for BALB/c over C57Bl/6 female urine. **b,** (C57Bl/6 × CBA/Ca) F_1 males and females show no preference between CBA/Ca and BALB/c female urinary odours, but favour BALB/c over C57Bl/6 female urine. Mean investigation times ± s.e.m. are shown; asterisks indicate $P < 0.05$ (Wilcoxon test). **c,** In habituation–dishabituation tests, BALB/c females cannot distinguish between reciprocal-cross F_1 male urines (no significant increase in investigation time for F1-1 and F1-2). **d,** The same mice can distinguish between C57Bl/6 and CBA/Ca urine. Mean investigation times ± s.e.m. are shown; asterisks indicate $P < 0.01$ (*t*-test). Further details of experimental procedures are available from the authors.

the maternal-strain (C57Bl/6) urine ($P<0.05$), but showed no preference between the control and paternal-strain CBA/Ca odours.

Reciprocal F_1 females were tested in the same way for which male urinary odours they favoured, but none showed any significant preference in either of the two tests. To ensure that this lack of a preference was not due to any impairment in olfactory function, we also tested these mice for their ability to distinguish between urine from C57Bl/6 and CBA/Ca males using a habituation–dishabituation test[7]. The females were found to have a normally functioning olfactory system, and were clearly able to distinguish between the two odour types ($P < 0.01$).

As our F_1 mice were derived by embryo transfer to unrelated foster mothers, the parent-of-origin effect on their odour preferences could not have been due to prior exposure to odour cues from their genetic parents. The odour preferences shown by reciprocal F_1 mice are probably 'hard-wired' by genes subject to parent-of-origin effects. It is unclear how this odour preference is determined in the reciprocal mice and at what level the effects are exerted. For instance, the genetic parent might influence the odour produced by the F_1 mice themselves. If genes subject to parent-of-origin effects influence normal odour type, then reciprocal F_1 mice should have different representations of their own odours, which in turn could affect their odour preference[8].

To test this idea, we examined the ability of BALB/c female mice to distinguish between the odours of reciprocal-cross F_1 males using the habituation–dishabituation paradigm. These females could not distinguish between the urines from reciprocal F_1 males (Fig. 1c; $P = 0.35$), but could readily distinguish urine from the individual parental strains (C57Bl/6 and CBA/Ca) (Fig. 1d; $P < 0.01$).

Our findings indicate that the parent-of-origin effect on odour preference in the offspring is not an acquired trait and that it may be due to differences in the functioning of the olfactory system in the reciprocal F_1 types, either at the level of perception or information processing. As these effects occur in mice of both sexes, they are probably due to autosomal imprinting and are not sex-linked.

Genes subject to a parent-of-origin effect that directly influences olfactory-related behaviour may have evolved to promote mechanisms of inbreeding avoidance, possibly by diminishing preference for maternal urine odour and thereby encouraging dispersal. If such a genetic system is to operate in outbred populations, the genes that determine odour and those subject to parent-of-origin effects acting on the perception of odours may need to be in linkage disequilibrium, for which there is precedent in both mice and humans[9,10].

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erratum

Watching fights raises fish hormone levels

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The Mann–Whitney test *P* values given in Fig. 1 were incorrect. In Fig. 1a, these should have been (from left to right) $P<0.05$, $P<0.01$ and $P<0.01$; and $P< 0.05$ in Fig. 1b.