tion, is grossly incorrect. The highly deviant pattern attributed to this child results from inaccurate formation stages combined with inaccurate standards. In addition, the true age of the child is unknown; van der Linden (personal communication) assigned the age of eight years based solely on dental age.

The impression given by Mann *et al.* that five- to six-year deviations in dental ages of teeth within individuals are common is contrary to published dental ages[16], the known high intercorrelation of dental development[17] and common experience. I do not deny the existence of variation (nor do I hold assumptions about variation ascribed to me[1]), but the argument that humans and apes are highly variable does nothing to further the case that early hominids can be regarded as human-like in growth. To the contrary, most of the early fossil hominids are both poor humans[3] and good apes[18] in developmental pattern, and a whole series of fossils, spanning millions of years, share a fairly typical ape-like pattern of development.

Fossils showing third molar calcification would be valuable additions, and future radiographic or scanning studies may provide these data. But one of the most interesting findings of new work on great apes[19] is that molar formation is not nearly as accelerated in these forms as had been supposed[2]. Findings for third molars of the Swartkrans hominids (the absence of M3 during eruption of M1 [Sk 63[2]] or the complete crown of M3 combined with completed M1 and advanced M2 root [SK 843[2]]) would be expected in humans[14], great apes[19] and macaques[20]. As this suggests, not all stages are diagnostic, and some portion of molar delay in higher primates probably represents a growth differential that separates anthropoids from prosimians.

Mann is a pioneer in the design of a question and a method, and especially in realizing that information as dynamic as pattern of growth and development might be retrieved from the hominid fossil record. Yet, new data, methods, and approaches[3,14,19–22] promise to enlarge our knowledge of the evolution of human growth and development.

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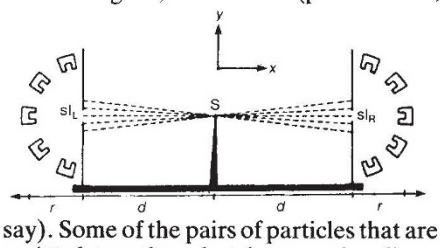
Popper versus Copenhagen

Sir—I am grateful to Collett and Loudon[1] for opening up a discussion of my 1982 proposal[2] for a crucial experiment between the (subjective) Copenhagen Interpretation of quantum mechanics and my own (objective) propensity interpretation — an experiment based upon Einstein, Podolsky and Rosen[3] and a radical simplification of another proposal by myself[4]. With the aid of a figure, let me briefly restate the experiment before replying to Collett and Loudon's criticism.

In the figure, S is a source (positronium,



say). Some of the pairs of particles that are emitted together, but in opposite directions, pass through the slits sl_R and sl_L of screens at equal distances (d), right (R) and left (L) of the source. After that they scatter and trigger coincidence detectors (at distance r). The width of sl_R and sl_L can be varied and, if the slits are narrowed, the range of the scatter becomes wider (diffraction) and vice versa. Now we remove the left screen. What will happen to the left range of scatter?

My prediction is that the diffraction scatter on the left disappears and the remaining scatter, by contrast, increases with increasing width of sl_R. The prediction of the Copenhagen interpretation is that the diffraction scatter on the left does not disappear and, as before, it becomes wider if we narrow sl_R because we indirectly measure the y-position of the particle on the left when it reaches $x = -d$, and it is our measurement or, according to Heisenberg, our knowledge, that creates scatter by the uncertainty principle. So the two interpretations arrive at opposite predictions; that is to say, we have a crucial experiment.

Collett and Loudon, although not very explicitly, agree with all this provided the source is fixed. But they say that the source must not be regarded as fixed: it is subject to (Heisenberg's) uncertainty principle. By an intricate analysis (open to severest criticism) they arrive, if I understand them correctly, at the conclusion that my prediction is tenable but that the prediction of the Copenhagen interpretation leads to a clash with it. So I must not claim that the experiment is crucial; or as they put it: "In summary, it has been shown that source uncertainty effects in the experiment proposed by Popper remove the distinctive increase in left-hand beam divergence with reduction in right-hand slit width that he ascribed to the Copenhagen interpretation of quantum mechanics".

My answer is that the source *is* fixed. For we have, for its position and momentum:

$$\Delta y \Delta p_y = \Delta y \Delta v_y m \approx h \qquad (1)$$

$$\text{and so} \quad \Delta y \Delta v_y \approx h/m \qquad (2)$$

But h/m can be made as small as we like. (Fixing our apparatus on rock, m becomes equal to the mass of the Earth.)

As to the "geometrical" uncertainty, discussed by Collett and Loudon, it does not matter that the source may reach from (say) y_1 to y_2, as long as this width is reasonably small; for Δv_y of the particles may still be made as small as we like by making d sufficiently long (keeping r constant).

Incidentally, Collett and Loudon's title[1] is slightly misleading. My experiment was never intended as a crucial experiment of quantum mechanics but only of its (subjectivist) Copenhagen interpretation (which they call "the standard interpretation"). In fact there exist several interpretations of the formalism (as became clear in the recent Schrödinger centenary celebrations, for example, in Jon Dorling's contribution[5]). Also, formulae (3) and (4) of Collett and Loudon cannot be obtained from (1) and (2) the way they say, because the square of (2) which they use is an area measure. But something on these lines might be done if (2) were replaced by $\lambda/4\pi$. The results are incompatible with their findings.

Karl Popper

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Collett and Loudon reply — We do not agree that the additional arguments made by Popper establish the ability of his proposed experiment to distinguish between the two interpretations of quantum mechanics he mentions.

One of the attractive features of the experiment as originally proposed by Popper was that the use of positronium as a source of particle pairs guaranteed that the two particles would come off in exactly