Re: Question regarding the evolution of the Right/Left Brain Division

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From: r norman (*rsn__at__comcast.net*)
Date: 12/19/04

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Date: Sun, 19 Dec 2004 05:37:00 +0000 (UTC)
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On Sat, 18 Dec 2004 18:50:53 +0000 (UTC), Tim Tyler <tim@tt1lock.org>
wrote:

>r norman <rsn_@_comcast.net> wrote or quoted:
>> On Fri, 17 Dec 2004 23:14:03 +0000 (UTC), "Curious in Minneapolis"
>
>> >The December 11 issue of The Economist magazine carried an article
>> >about lefthandedness. It suggested that the fact that the left side of
>> >the brain controls the right side of the body, and vice versa arose
>> >because "long ago in the evolutionary past, an ancestor of humans (and
>> >all other vertebrate animals) underwent a contortion that twisted its
>> >head around 180 degrees relative to its body."
>> >
>> >I am intrigued by this claim, which I have never heard before. Could
>> >someone offer more details about it? What empirical evidence is there
>> >for it? What do biologists suggest could have been the reason for this
>> >"contortion" or was it purely an accident? Is it possible that it never
>> >really took place, that there is actually some advantage to having this
>> >left−right crossover in the brain?
>> >
>> >I would be grateful if you could direct me to any good sources
>> >understandable to a layman regarding this phenomenon. Thank you.
>>
>> This "contortion" is the remnant of a very old (and discredited)
>> hypothesis to explain why many invertebrates have no crossing, between
>> right and left brain vs right and left sensory/motor function, a
>> ventral nervous system, and a dorsal heart whereas vertebrates show
>> the crossing and have a dorsal nervous system and a ventral heart.
>> However, it is quite likely that there was an early switch in the
>> developmental genes that determine body symmetry and differentiate the
>> left vs. the right sides. If the brain "chose" one set of criteria to
>> define which is left vs. which is right but the peripheral system
>> "chose" the opposite way, then things would cross.
>>
>> Whatever the cause, it is not true that somewhere in early evolution
>> the head of an ancestral vertebrate got twisted around 180 degrees on

>> the body axis.
>>
>> I don't know of any reasonable explanation for the crossover as an
>> adaptation or advantage. There have been some lame brained
>> explanations, but nothing that captures the enthusiasm of the majority
>> of scientists.
>
>http://publish.uwo.ca/~jkiernan/anfound.htm
>
>...offers information on the subject:
>
>``Comparative neuroanatomists cite decussations as an example
> of the continued exploitation of a structural feature that
> helped our lowly ancestors escape from predators more
> efficiently than their even more lowly competitors. Natural
> selection would not allow the loss of a decussating pathway
> if this were an advantage in a world full of other edible
> animals with non−decussating neural connections. In order to
> have left and right sides an animal must have different
> dorsal and ventral surfaces. The struggle for survival is
> supposed to have been among animals that lived where
> "dorsal" and "ventral" were significantly related to he
> surroundings (on the ocean floor,in shallow water, or on
> land). Even the most primitive nervous systems include motor
> and sensory neurons. A potentially fatal stimulus should
> evoke a movement of withdrawal, so that the attacked
> individual may survive and reproduce itself. The animal is
> more likely to escape by moving away from the assaulted
> side, especially if the predator is not smart enough to
> predict such a response. The fastest neuronal circuit for
> stimulating withdrawal to the other side of the midline is a
> monosynaptic reflex: a sensory neuron has an axon that
> crosses the midline and contacts motor neurons that make
> nearby muscle fibers contract. Such an arrangement makes a
> worm−like creature bend away from the attacked side. [...]''
>
>It goes on to give an explanation in terms of the left−right
>inverting property of camera lenses (appended).
>Unfortunately, I cannot see how this explanation makes any sense.
>
>I appreciate that sections of the optical cortex associated
>with near objects needed to be adjacent in the brain − so
>depth−processing of 3D objects could be performed by exchanging
>signals between nearby cells − but this does not need
>decussating pathways − you can produce that result by simply
>rotating the image through 180 degrees.
>
>I'm inclined to favour the first explanation: in ancestral
>creatures sensory fibres crossed and motor fibres did not (for
>adaptive reasons) − and we inherit the cross from them.
>

>Such a crossover can get permanently "locked in" − even if
>individual nerve fibres can cross back, it doesn't "pay" for
>them to do so.
>
>``Decussating pathways in vertebrates allow for the formation
> of congruent representation in the brain of images in the
> visual fields of the two eyes. The camera−type eye of
> vertebrate animals projects an inverted image onto its
> retina, so that events in the left half of the visual field
> of the left eye trigger neural signals that arise in the
> right half of its retina. If these signals were sent to the
> right side of the brain, the inverted projection would be a
> mirror image of the equivalent projection from the right
> half of the visual field (Fig. 16 −Uncrossed visual
> pathway).
>
> A decussating projection from the retina to the brain
> assures that the central topographic representations of the
> visual fields are correctly adjacent. In most vertebrates,
> the eyes see separate visual fields, and all the fibers of
> the optic nerve cross the midline (Fig. 17 − Completely
> decussating visual pathway). Some mammals (including man)
> have forward−facing eyes with overlapping visual fields. In
> this case the decussation of only the fibers from the medial
> half of the retina provides a correctly aligned
> topographical projection to the brain (Fig. 18 − Partial
> visual decussation).
>
> A visually guided movement is most likely to be needed on
> side from which the visual signal originates. Projection of
> the left and right visual fields to the contralateral tectum
> or cerebral hemisphere provides for rapid communication
> between the visual pathway and the motor neurons that work
> the muscles of the opposite side of the body. The visuomotor
> connections are ipsilateral in the brain but require a
> compensating decussation in the tracts that descend to the
> motor neurons (Fig. 17)."

As I said, there have been some lame−brained explanations, but none that have caught the enthusiasm of the majority of scientists.

The information you cite claims that very rapid escape mechanisms with monosynaptic connections would be most adaptive with a crossed system. Unfortunately, in the vertebrate spinal cord, the only monosynaptic connections (the stretch reflex) are distinctly ipsilateral −− the motor neuron is on the same side as the sensory neuron. The flexor reflex and associated crossed extensor reflex, a response especially to extremely strong and painful stimuli, is multisynaptic.

If an escape reflex must cross the midline from receptor to effector, it doesn't matter whether the sensory system crosses or the motor system crosses. However in the vertebrate system, if the escape reflex must control the same side as the stimulus, then either both sensory and motor must cross the midline, a system that takes longer pathways and hence takes longer time, or neither does, a system with shorter pathways requiring less time. Vertebrates use the former.

This whole argument makes no real sense when examined closely. One would expect arthropods to be subject to exactly the same evolutionary pressures as vertebrates, yet only vertebrates have the crossover.

Once you start talking about brain connections, the argument still makes no sense. Given the multiplicity of CNS interneurons involved, any "computed" response through the brain requires typically several hundred milliseconds to perform. Suppose the response latency is only several tens of milliseconds. At, say, 10 meters/second = 10 mm/msec conduction velocity for myleniated neurons in lower vertebrates, and given a brain even as large as one centimeter = 10 mm , it would take only 1 msec to go the extra distance of crossing. I am using very conservative values −− a relatively large brain for a protovertebrate and a relative slow conduction velocity for a myelinated axon. No, the argument about selective advantage for escape or for computational efficiency simply doesn't hold.

Most of the arguments presented would make even better sense if neither the sensory nor the motor systems crossed. Given that one is crossed, it does make good sense for the other to cross.

So, as I said to start with, I still don't see any good explanations that bear close examination.