Chapter 8: society – a community of brains

background reading

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notes

Constructive comments are welcome.

"***collectivism of thought***", Tudge 1996:260.

8.1 theory of mind

living in a mental environment

"***immersed in a constant process***" and "***very world we tread***", both from Landa 2013.

"***a mental world***" and "***mental states***", both from Wellman 2001.

"**This sentence may read oddly**", Frith 2006, Dunbar 2014a:45.

"***imagine a hypothetical being***", Wellman 1985:169, and quoted in Baron-Cohen 1997:59.

"**This is a brief description**", Baron-Cohen 1997:chapter 5.

"***can read people's actions***", Baron-Cohen 1997:59.

"**Someone who understands**", but why is it called "theory of mind"? A scientist uses a theory to explain the behaviour of entities that may not be directly perceptible, and thereby predict what they will do. We apply theory of mind to people's unobservable mental states, and thereby explain and predict their behaviour (Gleitman 2004:489, Baron-Cohen 1997:55).

"***make inferences***", Baron-Cohen 1985:39.

8.1.1 the Sally-Anne test for ToM

"**There are numerous tests**", Baron-Cohen 1997:70, Frith and Frith 1999, Dunbar 2004, Gleitman 2004:487 Kandel 2021:1526 and figure 62−2.

"**These children have understood**", we might think of theory of mind in a Western context, but it surely must be a universal human capability. For example, five-year-old Baka pygmy children in the rain forests of Cameroon were able to pass a version of the Sally-Anne test, so they could recognise a false belief and could predict how people would respond to it (Avis 1991, Whiten 2000:188).

Figure 8.1 is from Frith 2001:figure 1, and is reproduced here by kind permission from Axel Scheffler.

"**The false-belief test**", O'connell 2003, Frith 1999, Gleitman 2004:487.

"**The full mentalising ability**", Frith 1999. One group of subjects who typically cannot pass the Sally-Anne test are those individuals with autism spectrum disorder, ASD (Baron-Cohen 1997:chapter 5, Dunbar 2004:chapter 3, Frith 2001, Kandel 2021:1526). ASD is present in at least 1.5% of the population, and possibly as high as 2.6% (Kandel 2021:1526).

Many children with ASD learn to pass the Sally-Anne test, but on average with a 5-year delay. These children can have an excellent appreciation of physical causes and events. For example, "*a child who is incapable of falsely telling another that a box is locked is quite capable of locking the same box to prevent its contents from being stolen*" (Kandel 2021:1526).

It is found that more intelligent adults with ASD can pass the Sally-Anne test, but make errors in attributing intentions, for example, they confuse a lie with a joke and persuasion with misunderstanding (Fletcher 1995).

"***requires the representation***", Sommer 2007:5.

"**We perhaps take theory of mind for granted**", Simon Baron-Cohen gives an illuminating list of 8 important behaviours (Baron-Cohen 2000:262). See also note to section 8.6.2.

neuroimaging can distinguish between false and true belief reasoning

"**Neuroimaging studies**", Sommer 2007.

8.1.2 theory of mind and perspective-taking

"***other people have beliefs and desires***", Frith 1999.

"***beliefs about the world***", Dunbar 2005:59.

"***mental representations of the world***", Saxe 2006.

"***a subjective perspective***", Tomasello 2018:8491.

"**The child who passes**", the prepositions get a bit tricky here – whether to use "on" or "of". I'm using "perspective on" when it's about a person's frame of mind or their opinion, and "perspective of" when it's about what they can observe or perceive.

blue or green? – conflicting perspectives of the same object

"**A number of false-belief tests**", this test is in Moll 2013, and is also described in Tomasello 2018.

Figure 8.2 is based on Moll 2013:figure 3.

“***beginning to distinguish***”, Tomasello 2018.

8.1.3 a scale of mentalising skills

“**Theory of mind is not a single cognitive ability**”, Baron-Cohen 1997:chapter 4, Frith 2003, Wellman 2004 and 2011. Simon Baron-Cohen has proposed that the human capacity to mind-read comprises four components, comprising dyadic understanding between two people of (1) desires and goals, (2) perceptions, (3) shared triadic attention, and finally (4) the full theory of mind, that can understand mental states and relate them to actions. All four components are necessary for the full ToM capability. Baron-Cohen sees a core theory of mind as comprising a number of axioms, such as “*seeing leads to knowing*”, “*appearance is not necessarily the same as reality*” and “*people think that things are where they last saw them*” (Baron-Cohen 1997:55).

“**A typical progression**”, Wellman 2004 and 2011.

“**While the Sally-Anne test**”, Frith 1999.

“***theory-of-mind understandings***”, Wellman 2004:537.

8.1.4 do chimpanzees possess theory of mind?

“**Chimpanzees appear to possess**”, these examples are from Tomasello 2013, and Hare 2011 and Whiten 2013 have written helpful reviews. Hare 2011 summarises experimental findings which show that in many situations chimpanzees are capable of psychological state attribution – that is, they understand what others can see and hear, what they do or don’t know, and what their intentions are, and they are motivated to help. In many respects, chimpanzees are as capable as pre-verbal children.

“**We’ve seen an example of this**”, this raises the question: does Yeroen’s deception of Nikkie show that he has theory of mind? Yeroen put a lot of effort into deceiving Nikkie, perhaps in order to make Nikkie feel guilt and show sympathy (as Frans de Waal suggested), or to go easy on Yeroen, or maybe just to make Nikkie complacent. Yeroen acted in a certain way so as to put a false belief into Nikkie’s mind, or at least sustain his belief that Yeroen was injured, in order to achieve a certain behavioral outcome. “*The purpose of a lie, after all, is to instill a false belief; thus it is difficult to see how lies could be either produced or understood without some realization that beliefs can be false*” (Miller 2009:760). Yeroen shows that he recognises the possibility of a conspecific holding a false belief, and that this influences their behaviour, and so his deception of Nikkie seems to come very close to demonstrating theory of mind.

“**Observations of spontaneous behaviour**”, Kaminski 2008, Krachun 2010, Tomasello 2013.

“**In one of these experiments**”, Krachun 2010.

“**The mentalising abilities of chimpanzees**“, O’Connell 2003.

impression management

“**It is significant**”, Engelmann 2012.

joint attention and shared perspectives

“**The collective evidence**”, for example, see individual studies by Hare 2001, O’Connell 2003, Kaminski 2008, and Krachun 2010. The key experimental studies have been summarised and reviewed by Hare 2011, Whiten 2013, and Tomasello 2013 and 2018. The great majority of studies have been on chimpanzees, but recently bonobos have been receiving more attention (Hare 2011, Whiten 2013).

False-belief test have been done in a variety of ways, and some experimenters have included children from ages 3−6, and also individuals with autism, to provide context and comparison. Chimpanzees can usually out-perform 3-year-olds and autistic individuals (O’Connell 2003, Kaminsky 2008).

“***is not like understanding goals***”, Tomasello 2013:86.

“***I must judge that your representation***”, Tomasello 2018:8494.

“***a joint attentional interaction***”, Tomasello 2013:84.

chimpanzees

“**The most complex coordinated behaviour**“, see chapter 7, and Tomasello 2006:521. Tomasello noted that at the time of writing, there were no published accounts in which “*chimpanzees collaborate by playing different and complementary rôles in an activity*” (Tomasello 2006:521). I’ve made the case in chapter 7 that the Taï chimpanzees do play complementary rôles in their hunting expeditions, but this is in the context of one specialised activity, and is perhaps the nearest they get to theory of mind. I’m not considering any experimental studies of cooperation, because I’m looking for the natural precursors of human cooperation.

“***the notion of perspective***”, Tomasello 2013:85.

“***do not understand different perspectives***”, Tomasello 2018:8495.

children

“**Michael Tomasello**”, Tomasello 2018.

“***both are attending to X***”, Tomasello 2018:8494.

“***the coordination of three perspectives***”, Tomasello 2018:8495.

“**These constructive interactions**”, Tomasello 2018:8495. A number of studies have found that children with older siblings performed much better in false-belief tests, and this is ascribed to family life exposing them to different personal perspectives (McAlister 2007). Parents negotiating conflicts and reasoning with older siblings, fantasy play, cooperation, competition and disputes with siblings will all expose the pre-theory of mind child to differing and conflicting mental perspectives.

the importance of language

“**Nicaraguan Sign Language**”, Pyers 2009.

“***language learning***”, Pyers 2009:805.

the first human ancestors with theory of mind

“**How did they do this**”, we’ll see later in this chapter that our human ancestors probably passed the theory of mind threshold about 2½ million years ago. It appears that language evolved much later than this. Robin Dunbar concludes that “*the capacity for some form of language-like communication had to be in place by 500,000 years ago, but probably not a lot before*” (Dunbar 2009:27).

8.2 mentalising – a hierarchy of mind-states

8.2.1 theory of mind sets the threshold for level 8 of the hierarchy

"***I take my representation***", Tomasello 2018:8494.

"**Theory of mind is a hugely important step**", Thomas Suddendorf sees another consequence, for with theory of mind, the "*agent (the self) travels mentally in time*", so that she or he can hold mental representations of the past and the future and relate them to the present self. So, while " *we are changing dramatically in physical and mental make-up over time, all these stages are considered aspects of the same* ***me****. An extraordinary new structure appears to emerge: a sense of self that is not bound to time and body*" (both quotes from Suddendorf 2000:242).

"***The realization that beliefs***", Miller 2009:749.

"**The mentalising capability**", the transition from primates in Level 7 to humans in Level 8 is analogous to the transition from single-celled organisms in Level 5 to complex multi-celled organisms in Level 6. In both cases organisms that were highly capable as individuals came together in new communities to work towards a shared goal.

Simon Baron-Cohen lists 8 important social behaviours that depend on theory of mind (Baron-Cohen 2000:262). These are:

1) intentionally communicating with others
2) repairing failed communication with others
3) teaching others
4) intentionally persuading others
5) intentionally deceiving others
6) building shared plans and goals
7) intentionally sharing a focus or topic of attention
8) pretending

Without a theory of mind, none of these behaviours would be possible. For this reason, he sees the evolution of theory of mind in our human ancestors as important as the evolution of walking and language (Baron-Cohen 2000:261).

8.2.2 mind-states in the Sally-Anne test

"***Mentalising, or mindreading***", Dunbar 2020:55.

8.2.3 Intentionality and mentalising

"**Our look at the Sally-Anne test**", Dunbar 2004:chapter 3, Dennett 1989.

"***knowing, believing***", Dunbar 2004:45.

"***thinks, believes, wants***", Cheney 1990:142.

"**There are different levels**", psychologists regard theory of mind as a "*broad term, referring to the intentional stance … that characterizes human interaction*" (Astington 2003:15). For an explanation of the intentional stance see Dennett 1989. However, they don't work in orders of intentionality, but in understanding an individual's false-belief states. In this scheme, the Sally-Anne test is a 1st order false-belief task for the child subject, since the belief "*refers directly to some event in the world*" (Miller 2009:750). A 2nd order false-belief is "*a belief not about something in the world (as in the first-order case) but about someone else's belief about something in the world. Second-order reasoning of this form is thus recursive reasoning: A thinks that B thinks that …*" (Miller 2009:750). In the Sally-Anne test, the adult observer would be using 2nd order reasoning to assess the 1st order thinking of the child. So, the psychologist's 1st order false-belief reasoning corresponds to 2nd order intentionality, and their 2nd order reasoning corresponds to 3rd order intentionality.

While psychologists accepted that children's understanding of belief progressed beyond first-order reasoning, as of 2009, little research had been done on this (Miller 2009:749). Slaughter noted in 2003 that there was little work on children beyond the age of 7−8 or on adults, and there were "*few assessments that reveal significant and meaningful individual differences in mind reading*" (Slaughter 2003:5), and there was a "*lack of consensus on what constitutes a mature theory of mind*" (Slaughter 2003:6).

In this chapter, I've followed Robin Dunbar, Michael Tomasello, Dorothy Cheney and other primatologists and described the evolution of cognition in the human lineage in terms of levels of intentionality.

"***can be conceived***", Dunbar 2004:45.

"***has beliefs and desires***", Dennett 1989:345.

"**Someone with second order intentionality**", Dunbar 2004:45.

"**Thus, when Alice *believes* that Bob *wishes***", in this and future examples of mentalising, I use the standard alphabetic names for characters in cryptography protocols, see https://en.wikipedia.org/wiki/Alice_and_Bob.

8.2.4 higher mentalising states

levels of mentalising in children and adults

"**Children progress to higher levels**", Henzi 2007:figure 7, Dunbar 2009:35. Children typically pass 2nd order false-belief tasks (equivalent to 3rd level mentalising) around the ages of 7−8 years old (Slaughter 2003:4, Miller 2009:750).

"***children have typically mastered***", Dunbar 2009:35.

"**A group of normal healthy adults**", the mentalising profile is from Oesch 2017, and is consistent with Kinderman 1998, Dunbar 2004:figure 4, Stiller 2007 and Krems 2016. Oesch 2017 reports this approximate profile of normal healthy adults as capable of a particular mentalising level: level 3 – 100%, level 4 – 96%, level 5 – 78%, level 6 – 40%, and level 7 – 8% (figures derived from Oesch 2017:figure 1).

Kinderman's (1998) assessment of mentalising levels did not include the participant's mind-state, and so all the levels should be increased by one. This is corrected in later work, for example, Dunbar 2004:figure 4, which shows the majority of humans achieving level 5.

The small test group in Powell's study had the range 4−5.3, but with larger samples, Stiller found a range of levels from 2−8, and Oesch found a range of 3−7. Kinderman's data is for a sample of undergraduates, while Oesch's sample was predominantly undergraduates, postgraduates and working professionals, mainly from India and North America, so studies seem to have focussed mainly on adults with a high level of education.

"**There is some suggestion**", Stiller found that women achieved significantly higher levels than men, with the women's average score being about one level higher than the men's, and Oesch 2017 found the difference to be about half a level, although Powell 2010 found no significant difference.

What does higher level mentalising look like?

"**Robin Dunbar gives an example**", Dunbar 2004:figure 3, also in Dunbar 2014a:figure 2.2.

"… **an example of 5th level mentalising** …", Dunbar 2004:chapter 3 and 2009:35.

how do we measure a person's mentalising ability?

"**The established way**", Kinderman 1998, Dunbar 2004a, Stiller 2007.

"**Here is one of the stories**", this is only one of the stories used by Stiller, and other stories went to higher levels. Each story was followed by a set of questions testing the subject's factual memory of events in the story, as well as mentalising questions, and only the mentalising questions are included here. An example of a story used in assessing mentalising in children is given by Henzi 2007.

The story "Emma's Dilemma" and selected questions are reprinted from "Social Networks", volume 29(1), James Stiller and R.I.M. Dunbar, "Perspective-taking and memory capacity predict social network size", pages 93−104, Copyright 2007, with permission from Elsevier.

the cognitive demand of high level mentalising

"**Test subjects typically could answer**", Lewis 2017:figure 2. This study also showed that mentalising tasks are cognitively more demanding than factual recall tasks, and that higher level mentalising draws on greater neural resources, especially those regions in the frontal and temporal lobes (Lewis 2017).

8.2.5 the breadth and depth of mentalising

breadth – multiple mentalising

depth – recursive mentalising

"**In dyadic mentalising**", see Dennett 1989 and Cheney 1990:chapter 5.

"**Now, the mentalising extends**", dyadic mentalising only involves two people, so I've called this polyadic, because it involves many people.

multiple and recursive mentalising make different cognitive demands

"**So, recursive mentalising**", Krems 2016 followed the established convention of counting levels of intentionality, and considered that "*a level of intentionality is "used" whenever one models the mind of another person and regardless of how one comes to know that mindstate*" (Krems 2016:note 2). The simple examples given here suggest that this is not the case.

8.3 mentalising in conversation

8.3.1 a "conversation" with no theory of mind

"***without theory of mind***", Dunbar 2009:30.

Simon Baron-Cohen sees autism as giving "*a clear illustration of what human life would be like if one lacked a theory of mind. The most devastating effect is on the ability to socialize, communicate, and use imagination*" (Baron-Cohen 2000:266).

8.3.2 the conversation "jigsaw"

"**For two people to have a meaningful conversation**", Frith 2006:533.

"***I ask you a question***", Front 2014:45.

The excerpt is from "Curious True Stories and Loose Connections", by Rebecca Front, © Rebecca Front 2014. Reproduced with permission of the Licensor through PLSClear.

"***has to monitor the hearer***", Dunbar 1998b:101.

"**The exchange of thoughts and feelings**", this seems to be analogous to the exchange processes that bind entities together in communities at every level in the hierarchy.

strangers need to keep it simple

8.3.3 the motivation to communicate

"***exploit another individual's view***", Dunbar 2004:44.

"**This simple example**", this is one of Simon Baron-Cohen's 8 behaviours that depend on theory of mind. Thus, to intentionally inform others, "*one needs a concept that others have minds that can be informed or uninformed*" (Baron-Cohen 2000:262).

8.3.4 the mentalising demands of speaking and listening

"***has to intend that the listener understands***", Dunbar 2014a:241, and this exposition is also in Dunbar 1998b:101 and in Dunbar 2016:131.

"**For her to communicate effectively**", a set of nested mind-states can also be represented as a mathematical expression. So, Alice's mind-state in figure 8.8, represented by the letter string **ABA**, can also be represented by the expression, $A^3(B^2(A^1(\circ)))$. Similarly, Bob's mind state can be represented as $B^2(A^1(\circ))$.

"**For there to be a meaningful conversation**", Robin Dunbar says that "*the speaker probably requires third order*" (Dunbar 2014a:241), but it looks more definite than that.

8.3.5 mutual assurance of theory of mind

"**If you and I want to cooperate**", the situation shown in figure 8.9 raises the thought that 4th level dyadic mentalising might only be possible with a sophisticated language, even though it has been very difficult to put into words, and in fact, it was easier to draw the figure than to describe it. But it appears that our human ancestors started developing higher mentalising skills around 2 million years ago, which was almost certainly before the evolution of complex language, and this is covered in section 8.3.

"**We can see that with progressively higher levels**", Dennett 1989:244 says "*there seems to be no interesting difference between, say, a fourth-order and a fifth-order intentional system*", and the situation shown in figure 8.9 agrees with this, because if 4th level mentalising assures both individuals that they are each working at the 2nd level, what extra benefit would 5th level mentalising bring? But Dennett's examples of mentalising are dyadic, and in the case of polyadic mentalising, 5th level mentalising is distinctly different from 4th level. We'll see that you need 4th level mentalising to follow a story like Othello, but 5th level to write it. And Dunbar 2008:415 sees 4th level intentionality as sustaining social religion, but 5th level sustaining a communal religion, which he describes as "*a set of beliefs that bind us into a single community whose members share the same world view*".

8.3.6 a conversation about Carol

Alice's mind-state in **figure 8.10**, represented by the letter string **ABAC**, can also be represented by the expression, $A^4(B^3(A^2(C^1(\triangle))))$.

8.3.7 the cognitive demands of conversation in groups

"**In this section, we will look at the level of mentalising**", Krems 2016 suggests that not all conversations require recursive mind-reading (Krems 2016:note 3), and this may be the case where one person does most of the talking. Here I'm considering a free and balanced conversation, where all are following what is being said, and participate more or less equally.

a clique of three talk about a can of beans

a clique of four talk about a can of beans

gossiping about Eve

8.3.8 the sizes of conversation cliques

“**Moreover, they must be able to do this**”, Slaughter 2003:7.

“***social dysfunction may sometimes be characterized***”, Slaughter 2003:7.

“**All these are found to be true**”, Dunbar 1995, Krems 2016, Henzi 2007.

“**Cliques break up**”, Dunbar 1995, Krems 2016.

“**In groups in which cliques form freely**”, Dunbar 1995, Krems 2016.

“**All this supports the first inference**”, there are a number of factors that make conversation more difficult for larger cliques. For example, the ambient noise level rises, participants are spatially more distant, there are problems taking turns to speak, and people may speak over each other. However, it seems that maximum clique sizes are set by the limits of mentalising.

“**More significantly**”, Krems 2016.

“***modelling the mind***”, Krems 2016.

“**Concerning the third inference**”, Henzi 2007:figures 1 and 7.

8.3.9 permutations of recursion

8.4 the evolution of modern humans

8.4.1 a series of disillusionments

“***humans are unique***” and “***requires a special kind of explanation***”, Lewin 1999:4.

“**Consequently, the development of our understanding**”, many of these are discussed by Leakey 1994.

“***a long corridor***”, Tooby 1987:203.

8.4.2 primates

“**Linnaeus considered humans**“, Tudge 1996:165, and see also Lewin 1999:chapter 1.

“Primates evolved”, Baggott 2015:313, Purves 1998:684.

“**A series of splits**”, Purves 1998:684, Lewin 1999:chapter 10, Morowitz 2002:chapter 25, Campbell 2008:726, Boyd 2012:chapter 5, Dunbar 2014a:3, Tudge 2009:114 on prosimians.

“**All primates**”, Morowitz 2002:140.

“**The major traits**”, Purves 1998:684, Campbell 2008:723, Tudge 1996:168, Morowitz 2002:chapters 23 and 24, Boyd 2012:chapter 5.

“***the clinging of young***”, Morowitz 2002:142.

“***extreme generalness***” and “***possess very few features***” and “***human beings***”, Tudge 1996:165 and 167.

“**Evolution has no long-term goal**”, evolution is clear in retrospect, for there is one path by which a past species has evolved into a present one, even if we can’t see all the steps. But evolution is quite unpredictable in prospect, for we can’t take a species and foresee how it will change, and what it will evolve to become.

“***we do see a wonderful chain***” and “***an ape that could***”, Tudge 1996:176−177.

8.4.3 a series of splits

“**Around 10 million years ago**”, Dunbar 2014a:5.

“**Genetic and fossil studies**”, from DNA data: Lewin 1999:unit 15, Lieberman 2010, Stringer 2011b:chapter7, Leakey 1994:6; and from fossil evidence: Lewin 1999:unit 16, Kingdon 2003:chapter 4). Interestingly, DNA studies suggest that human and chimpanzee *Pediculus* lice diverged into separate species around 5.5 million years ago, in line with the time of the last common ancestor (Weiss 2009).

“**A split around 8 million years ago**”, Dunbar 2014a:5. For the distinction between hominids and hominins, see Dunbar 2014a:8.

“**The members of the lineage**”, it used to be thought that chimpanzees and gorillas were more closely related to each other than to humans, and in this arrangement, the great apes were called hominoids, and species that were more closely related to humans than to apes were called hominids. Molecular DNA studies have shown that the *Pan* species, chimpanzees and bonobos, are more closely related to humans than to gorillas, so species that are closer to humans than to *Pan* are now called hominins (Harcourt-Smith 2010).

In quotes that use the older term, “hominid”, this has been replaced by “hominin”.

chimpanzees and bonobos

“**In the 2 million years**”, de Waal 1997 and 2006. There are significant differences between chimpanzees and bonobos (see de Waal 1997:chapters 2, 3 and 5), but I’m not concerned with those here, nor am I going to look at the diversity of primate social systems (see, for example, Dunbar 1988, Wilson 1975).

In some respects, adult bonobos behave like adolescent chimpanzees. For example, chimpanzees readily share food when young, but this decreases as they grow to adulthood. In contrast, adult bonobos share food as readily as juveniles (Lieberman 2013:30, Wobber 2010)

“**For example, the bonobo**”, de Waal 1997:24 and 26.

“***sensitive, lively, and nervous***”, “***physical violence almost never occurs***”, “***no quicker way to distinguish***”, all from de Waal 1997:9.

“***drop straight out of the tree***”, de Waal 1997:59 and 2006:15.

“***we should keep in mind***”, de Waal 1997:143.

“**In genetic terms**”, the DNA genomes of humans and chimpanzees differs by about 1.6%, and the difference between humans and bonobos is similar. The human/gorilla difference is about 2.3% (Morowitz 2002:143).

To compare the human and chimpanzee genomes in terms of a single percentage is highly simplistic. Boyd puts the difference at about 1.1%, and explains that this means that in 1.1% of all the nucleotides in the human genome, humans and chimpanzees differ (Boyd 2012:305). Each nucleotide carries a DNA base, adenine (A), cytosine (C), guanine (G) or thymine (T), and the human genome has about 3 billion bases, so a 1.1% difference means about 30 million bases are different between humans and chimpanzees. But, how are these base differences distributed across the genome? One study identified about 13,500 homologous genes that humans and chimpanzees have inherited from their common ancestor, when the two lineages diverged about 6 million years ago. Comparison of these homologous genes showed that the difference was far more than 1%, and that about 70% of them differed by 2 bases on average, and so produced different proteins. So, a small overall difference in

DNA, concentrated in selected genes, can produce a very big phenotypic difference between closely related species.

"***human society is characterized***", de Waal 1997:136.

"**Humans and chimpanzees**", de Waal 1997:5.

"**Genetic variation**", Patterson 1999:82.

the last common ancestor

"**We don't know**", Dunbar 2014a:5. Both chimpanzees and bonobos are taken as models for the early hominins, for example in the development of upright walking (De Waal 2006:8). We have to be careful in making comparisons, for chimpanzees and bonobos have become distinct species, in both behaviour and anatomy, in the 2 million years that they have been separately evolving (de Waal 2006:7).

Daniel Lieberman sees the balance of evidence suggesting that the first of our hominin ancestors were not very different from today's chimps and gorillas (Lieberman 2013:30).

8.4.4 the changing climate

"**Over the last 4 million years**", Potts 1998:figures 1−3, deMenocal 2004:figure 11, and deMenocal 2011. Potts summarises the Earth's climate during hominin evolution, and reviews the different hypotheses linking climate changes to human evolution. Many hypotheses propose that humans evolved to survive in specific habitats. For example, the savannah hypothesis, which proposes that human evolution has been driven by the shift in habitat from forest to open grassland, was favoured until the mid-1990s (Potts 1998:110).

"**The overall pattern**", deMenocal 2004:8, Stringer 2011a:56. From about 4−3 mya the Earth's climate was influenced by the the tilt of its axis and the shape of its orbit round the sun. As the Earth slowly cooled, ice sheets built up at high latitudes near the poles, and around 2.8 mya these became sufficiently extensive that they imposed short-term climate variations with periodicities of about 40,000 years, from 3−1 mya, and then about 100,000 years, from 1 mya to the present (deMenocal 2004:figures 2 and 11).

"**For example, between 15,000 and 5,000 years ago**", deMenocal 2011, and there is a graphic illustration of the extreme variation in biological habitats in Boyd 2012:figure 12.20.

"**Underlying the wet/dry cycles**", deMenocal 2004:13, and 2011.

"**The more extensive grasslands**", deMenocal 2004:17, and 2011:panel F.

"**For example, one study**", deMenocal 2004:figure 10.

"***frigid highland to parched valley floor***", Leakey 1993:85.

"**Furthermore, this mosaic environment**", Potts 1998:130, Kingdon:chapters 3−5, Leakey 1994:16. The majority of Australopithecine habitats were situated above 1,000 m (Dunbar 2014a:114).

"**Instead of being habitat specialists**", Potts 1998:131, deMenocal 2004:18 and 2011:541.

Cat Bohannon captures the experience of rapid environmental changes, where the weather is "*swinging between wet and cool and hot and dry in just a few thousand years. There's a lake, then no lake. There's a forest, then a grassland, then a desert, and back again to a forest. As a rule, simple mutations aren't going to be fast enough to adapt to a world that changes wildly every thousand generations*" (Bohannon 2023:271). In such a constantly changing environment, "*it's the species that are **less** specifically adapted to an ecological niche who are the ones most likely to make it*" (Bohannon 2023:270).

8.4.5 the suite of human features

"**The human species can be characterised**", I wish I could claim this neat epigram as my own, but I can't. I found it in our local library, in a guide to walking holidays. I've been unable to locate the book since, so I can't acknowledge its author. But it sums things up very well – with each of us somewhere on an axis with locomotion at one end, and cognition at the other.

"***there is no one point***", Dunbar 2004:31.

8.4.6 one theme in human evolution

The account of human evolution given here is very brief, and becomes even more sketchy after our ancestors acquired theory of mind. Daniel Lieberman tells a much fuller story of human physical evolution up to the present day (Lieberman 2013).

Yuval Noah Harari surveys human history since the "cognitive revolution", about 70,000 years ago (Harari 2015). It was probably around this time that humans became capable of 5th level mentalising, and our cultural development since then has been based on a "*belief in shared myths*" (Harari 2015:41 and 117).

"***must be told***", Dunbar 2003a:163.

Simon Baron-Cohen considers that the evolution of a theory of mind in hominins was not only as important as the evolution of other capabilities, such as bipedalism and language, but in some respects was more important (Baron-Cohen 2000:261). However, we'll see that our human ancestors went way beyond theory of mind, or 2nd level mentalising.

"***the question of how we eventually came to be human***", Dunbar 2014:343.

"***we suspect that***", Cheney 2007:279.

"**Evolutionary pressures**", John Gowlett divided the 6 million years or so of human evolution into two halves. The first half involved "*adaptations of bipedalism and life in wooded environments*", and the second half involved adaptations which were "*committed to long ranging, open environments, meat eating and other new foods*", but he didn't include the enlargement of the brain (Gowlett 2016:2).

"**Locomotion and cognition**", Gowlett recognised that "*the evolutionary sequence is firmly anchored at both its ends – at one end among the great apes … and at the other end in modern humans*" (Gowlett 2012:694).

Figure 8.13 covers only the major hominin species that are considered to be ancestors of humans, and is based on a number of sources: Boyd 2012:figures 10.13 and 10.36 and chapters 10−12, Dunbar 2004:figure 2, 2009:figures 2.3 and 2.6 (which are based on de Miguel 2001), and 2014a:figures 1.2 and 1.3, Eccles 1991:figure 2.13, Foley 2009, Harcourt-Smith 2007:figure 5.1 and 2010, Lewin 1999:units 19, 21 and 24, McHenry 2000, de Miguel 2001:figure 2, Schoenemann 2006:figure 2, and Stringer 2011a:131.

These sources differ in the values they give for fossil brain sizes and dates, and in their allocation to a hominin species, and I've selected the values that are representative of the majority of sources. Estimates of fossil brain sizes can carry substantial errors, for example, estimates of the brain size of one *A. africanus* cranial fossil by various investigators ranged from 513−625 cc (de Miguel 2001:14).

Every hominin species can be represented as a scatter of points on the brain size/time plot (see for example, Dunbar 2004:figure 2, and Dunbar 2009:figure 2.6), and to keep the plot simple I've indicated the regions for the hominin species (as has been done in Eccles 1991:figure 2.13 and in Stringer 2011a:131). The fossil data suggests that the brain size for a species can increase during the time it exists, and this is shown for some of the species in the plot (Dunbar 2009:figure 2.3).

Brain volume is plotted up the left-hand axis in cubic centimetres (cc), where 1 cc = 1 millilitre (ml).

The mentalising level is plotted up the right-hand axis, and the scale has been made simply by putting chimpanzees a little below level 2 and humans at level 5, and assuming a linear relationship between mentalising level and brain volume, and hence spacing the intervening levels equally. The linear relationship is only an assumption, and so these intervening levels are put in brackets to reflect their uncertainty, and the grey bar shows the approximate range of normal adult mentalising levels. The tentative mentalising scale suggests that an increase in brain volume of about 300 cc raises the mentalising ability by one level.

Concerning brain sizes for current humans, two things are clear: (1) on average, males have significantly larger brains than females, and (2) there's a wide range in brain sizes for both sexes. Molina (2012, 2015) gives these figures: men, range 1,070−1,767 cc, average 1,407 cc; women, range 1,000−1,618 cc, average 1,233 cc, and these figures give a species average of 1,320 cc. Henneberg (1990:table 1) gives averages of 1,427 cc for males, and 1,272 cc for women, giving a species average of 1,349 cc, which is fairly consistent with Molina's values. DeSilva reviews a number of studies and arrives at a very similar species average value (DeSilva 2023).

The solid bars and circles on the right hand axis, give the ranges in brain sizes and the average values for current chimpanzees (Schoenemann 2006:figure 2), and for humans (Molina 2012 and 2015). The range in human brain size is remarkable. Ralph Holloway gives the range as 900−2,000 cc, with male brains being ~10% bigger than female brains (Holloway 2004:12 – weight in grams and volume in cc are numerically very close, since brain density is close to 1 g/cc).

The geological timescale is taken from Boyd 2012:figure 12.4 and Lewin 1999:27.

Homo habilis, or "handy-man", is so named because of the association with the first stone tools. *Homo ergaster* is named after the Greek work for workman, because of the extensive use of this new lithic technology. The species, *H. erectus*, are named for their tall and upright posture (Kingdon 2003:262).

De Miguel plotted hominin fossil brain sizes over the last 3.2 million years, without regard to species, and derived a long-term trend line, based on a double exponential equation, which accounts for 90% of the variance in brain size, and this is shown in de Miguel 2001:figure 2.

I've adapted this trend line in two ways. First, I've used the de Miguel equation to estimate hominin brain sizes from 3.2 mya back to 6 mya, and we can see that the extended line is consistent with the measured brain sizes of the *Orrorin* and *Ardipithecus* fossils. Second, the de Miguel equation gives a value of 1,480 cc for the average brain size of modern humans, which is at odds with the measured values of 1,320−1,350 cc given above. The trend line in figure 8.13 follows the de Miguel trend line from 3.2−1.0 mya, and then gradually diverges from it, while still maintaining the ever-steepening curve, and ends up at the correct current brain size of 1,320 cc. This modified trend line gives an increase in hominin brain size of roughly 900 cc in 3 million years.

How can one describe the accelerating trend in brain enlargement over the last three million years? We can look at the trend in terms of arithmetic growth, where the brain size increases in six steps, each of 150 cc, as follows …

brain volume/cc	440		590		740		890		1,040		1,190		1,340
time/mya	3.00		1.74		1.15		0.75		0.45		0.18		0
time lapse/My		1.26		0.59		0.40		0.30		0.27		0.18	

The arithmetic growth pattern shows that the time decreased for each successive step, so it took about 1.3 million years to add the first 150 cc of extra brain volume, but less than 0.2 million years to add the last 150 cc.

Has hominin brain size increased steadily with time, or have there been sudden increases at certain times? The sparsity of fossil evidence leaves us uncertain, and the plot of brain size with time can be seen either way (see Lewin 1999:192). However, there are apparent irregularities in the pattern, which suggest that there may have rapid increases in brain size at certain times. Robin Dunbar considers that there have been a number of jumps in brain size, one occurring about 2 mya, with the appearance of *H. erectus*, and a second at about 0.7 mya, with the appearance of archaic humans, and he links both events with major climatic instability (Dunbar 2009:24). He also sees a third a third jump occurring about 300,000 years ago, and has linked this to the control of fire, enabling cooking and an improvement in diet (Dunbar 2014a:190 and figure 6.2). Richard Wrangham has argued for discrete steps in brain expansion, fuelled by improvements in diet (Wrangham 2009:114).

Figure 8.13 presents human evolution in just two major stages, involving the development of locomotion and of cognition. Daniel Lieberman sees human bodies evolving in 5 transformations: (1) becoming upright bipeds; (2) adapting to forage for a wide range of foods; (3) becoming hunter-gatherers with slightly larger brains and nearly modern bodies; (4) developing larger brains; and (5) becoming modern humans, with language, culture and cooperation, and spreading across the Earth. To these he adds two further transformations, due to cultural evolution: (6) the agricultural revolution, when humans took up farming, and (7) the industrial revolution, when humans began to use fossil fuel energy and machines to replace human work. (Lieberman 2013:18−20).

From the graph one might think that there has been an unbroken trend of brain enlargement, but this is not the case, for the average human brain size has decreased slightly, but significantly, since the end of the last ice age, about 10−12 thousand years ago (Lieberman 2013:335, DeSilva 2023). "*Human brain volume has decreased by a standard deviation in the last 10,000 years … an overarching global reduction in human brain size*" (DeSilva 2023).

Neanderthals are sometimes described as having larger brains than modern humans (Lewin 1999:156, Lieberman 2013:104). Whilst this is correct, Neanderthals and humans had similar brain sizes when they co-existed about 100,000 years ago (DeSilva 2023:figure 1). Since that time, Neanderthals have died out and the average human brain size has decreased.

This has been ascribed to the agricultural revolution and the subsequent rise of complex societies (DeSilva 2023). Certainly, cognitive demands have changed hugely as humans have gone from being hunter-gatherers, to farmers, and then to specialists in an industrial society.

Hunter-gatherers "*did not forage only for food and materials. They foraged for knowledge as well. To survive, they needed a detailed mental map of their territory. To maximise the efficiency of their daily search for food, they required information about the growth patterns of each plant and the habits of each animal. They needed to know which foods were nourishing, which made you sick, and how to use others as cures. They needed to know the progress of the seasons and what warning signs preceded a thunderstorm or a dry spell.They studied every stream, every walnut tree, every bear cave, and every flint-stone deposit in their vicinity. Each individual had to understand how to make a stone knife, how to mend a torn cloak, how to lay a rabbit trap, and how to face avalanches, snakebites or hungry lions. Mastery of each of these many skills required years of apprenticeship and practice*" (Harari 2015:54). In contrast, people in agricultural and industrial societies "*could increasingly rely on the skills of others for survival … You could survive and pass on your unremarkable genes to the next generation by working as a water carrier or an assembly-line worker*" (Harari 2015:55).

A forager very probably had a more interesting lifestyle than a modern industrial worker. To take one example, "*a Chinese factory hand leaves home around seven in the morning, makes her way through polluted streets to a sweatshop, and there operates the same machine, in the same way, day in, day out, for ten long and mind-numbing hours, returning home about seven in the evening in order to wash dishes and do the laundry*" (Harari 2015:56).

"**Following the first approach**", Dunbar 2014a:9−17.

"**Nearly 1 million years ago**", Boyd 2012:chapter12, Dunbar 2014a:chapters 6 and 7.

"**If we follow the second approach**", the increase in brain size over the last three million years is "*best characterised as a gradual time trend*", since it appears to indicate a gradual and smooth increase in brain size with time, with little relation to the appearance of new hominin species (de Miguel 2001:figures 1 and 2, Schoenemann 2006:388 and 2013:155, and quote from de Miguel 2001:3).

"**We can be confident**", Dunbar has derived regression equations to correlate intentionality (mentalising) level with brain volume (Dunbar 2009:table 2.3). He did this by plotting intentionality against frontal lobe volume for chimpanzees and humans (Dunbar 2009:figure 2.5 and 2014a:figure 2.4), and assuming a linear relationship between the two variables. He then linked frontal lobe volume to total brain volume, using the assumption that frontal lobe volume is about 37% of total brain volume (Dunbar 2009:table 2.3).

On this basis, Dunbar proposed a linear relationship between intentionality level and total brain volume, roughly as follows: ~400 cc, level 2; ~700 cc, level 3; ~1,000 cc, level 4; and ~1,350 cc, level 5. This correlation suggests that an extra 300 cc in hominin brain volume raises the intentionality level by one.

These figures are based on a comparison of figures 2.3 and 2.6 in Dunbar 2009. I've used Dunbar's graphs because these are used in his publications, and because his regression equations give different figures, which don't seem to match the graphs. Dunbar's various plots of intentionality levels for different hominin species show broadly the same picture, an accelerating rise from the 2nd to the 5th levels, but mean values and ranges for individual species can differ by half a level (Dunbar 2009:figure 2.6, 2014a:figure 7.4, and 2020:figure 4).

However, this correlation between intentionality and total brain volume is uncertain for three reasons: (1) human intentionality is put at level 5, but the range is 4−6 or greater; (2) it is based on intentionality levels only for chimpanzees (put at level 2) and humans (put at level 5); and then (3) it assumes a linear relationship between these extremes.

So, we can only have confidence in the ends of the mentalising scale, with chimpanzees close to level 2 and the majority of humans at about level 5, and we can only approximate the levels in between. The mentalising scale in figure 8.13 is constructed on this basis. The intervening levels are equally spaced, but put in brackets to reflect their uncertainty, and the grey bar shows the approximate range of normal adult mentalising levels. This rough scale is based on an assumption of a linear relationship between intentionality and brain volume, and so it is consistent with Dunbar 2009:figure 2.6, 2014a:figure 7.4, and 2020:figure 4.

"**Robin Dunbar has correlated**", Dunbar 2009:table 2.3 and figures 2.3, 2.5 and 2.6, Dunbar 2014a:figures 2.4 and 7.4, and Dunbar 2020:figure 4.

"**The trend towards larger brains**", Schoenemann 2006:388, Schoenemann 2013:155. *Orrorin* and *Ardipithecus*, earlier species in the hominin lineage, had brain sizes that were around 300 cc, which means that brain growth was only about 100−150 cc in 3 million years. So brain enlargement was negligible before about 3 mya, and only after that time did it become a significant trend. We'll see later in figure 8.14, how *A. africanus* was the first species to break out of the allometric brain-body correlation for the higher primates.

"**In mentalising terms**", I'm looking at broad trends, and so I'm not considering how recently our species became capable of level 5 mentalising.

8.4.7 towards a community of minds

"***so great that it cannot yet be measured***", Wilson 1975:548.

"**So, the inexorable and accelerating trend**", we know that the rate of brain enlargement accelerated, but since we can't directly relate brain volume to mentalising level, we can't say with any confidence if the rate of increase in mentalising level was accelerating – that is, if it took progressively less time to increase the mentalising level by one.

8.5 the evolution of locomotion

"**Human bipedality has developed**", this is based on Harcourt-Smith 2007:figure 5.2, and the times are approximate.

8.5.1 the first stage: about 6−4.5 mya, arboreal – occasional walkers

"**Modern chimpanzees and bonobos**", it's worthwhile thinking about the geometry of terrestrial and arboreal habitats. The terrestrial habitat is simply a horizontal two-dimensional surface. The arboreal habitat is one-dimensional, when the animal is climbing a tree trunk or moving along a branch. But where there are two branches, one above the other, the terrain becomes two-dimensional – but vertical, not horizontal. We remark on arboreal primates, such as chimpanzees, as having an "upright" stance, but they are only aligning their posture to their vertical 2-D terrain. Consequently, "*a somewhat bipedal arboreal lifestyle is probably the default mode for apes*" (Wilkinson 2016:53). This leads us to the counter-intuitive conclusion that life in the trees enabled our human ancestors to adapt to a bipedal lifestyle on the ground. They learned to stand and walk upright without having to steady themselves by holding on to an upper tree branch.

Matt Wilkinson has pointed out a major difference between the quadrupedal gaits of terrestrial mammals and arboreal primates (Wilkinson 2016:59). Most mammals walk with a lateral sequence gait, which gives them stability on two-dimensional flat ground. Primates use a diagonal sequence gait, which gives them better stability and security on a thin, one-dimensional tree branch. This primate gait shifts more of the body weight on to the hind limbs, which makes it easier to stand fully upright, and use the hands for picking leaves or fruit or for holding on to a higher branch.

"***arboreal or terrestrial specialists***", Harcourt-Smith 2007:1484. An arboreal lifestyle involves being upright to climb a tree trunk, and to reach up to swing on a branch or to reach fruit from above. The arboreal primates were elective uprights, and this naturally led to them being electively bipedal. The arboreal lifestyle also discriminates between the front and back limbs, so the front become hands, and the back become feet. The hands don't just support and cling, but start to become important in manipulating objects, the start of hand-eye coordination.

"**The early hominins inhabited**", Potts 1998:114 and 116, Lewin 1999:95, Harcourt-Smith 2010:335, Stringer 2011a:207. It's long been thought that our human ancestors became bipedal in order to move about on the hot open savannah, but it's now recognised that the earliest hominins lived in well-wooded environments, similar to current chimpanzees.

"**The climate was becoming drier**", Foley 2009. It's now generally accepted that from 6−4 mya the early hominins lived in a wide variety of habitats, and that there was a drying trend, and a shift from closed to open vegetation, and many arboreal species became more terrestrial (Foley 2009:3273, Stringer 2011a:207).

Between 10 and 5 million years ago, the Earth's climate steadily cooled, and the long-term effect was "*to cause the rain forests to shrink and woodland habitats to expand*" (Lieberman 2013:40). There would be little change for primates living in the heart of the rain forest, but big changes for primates living in the forest margins. The ripe fruits that were the major part of the diet became less abundant, more dispersed, and more seasonal. In Daniel Lieberman's view, the evidence most strongly supports the idea that "*regularly standing and walking upright was initially selected to help the first hominins forage and obtain food more effectively*" as close forest became open woodland.

"**The first stage in the development**", the fossils of *Ardipithecus* and tree-dwelling colobus monkeys are found together, providing good evidence that these hominins lived in forested habitats (Stringer 2011a:207).

Three species represent the earliest human ancestors: *Orrorin*, *Ardipithecus* (shown in figure 8.13), and *Sahelanthropus tchadensis* (sometimes called Toumaï), and their fossils have features suggesting they were adapted to walking upright (Lieberman 2013:33). These features include a femur with a large hip joint (*Orrorin*), a skull supported by a nearly vertical upper spine (*Sahelanthropus*), an S-shaped spine (*Sahelanthropus*), and a partly stiffened foot with flexible toes that can push on the ground (*Ardipithecus*). These species were not quadrupedal on the ground, but were occasional bipeds, walking with more efficiency and stability than chimpanzee, but not striding as well as modern humans. They were still adept climbers, but less agile than chimpanzees (Lieberman 2013:34−8).

"**The earliest hominins**", on *Orrorin*, see Harcourt-Smith 2007:1491, Boyd 2012:223, Dunbar 2014a:9.

"**For example, the foot of *Ardipithecus***", Harcourt-Smith 2010, Stringer 2011a:206, Lieberman 2012, Boyd 2012:224.

the energetics of locomotion

"**We quantify this energy**", the cost of transport is sometimes measured in terms of oxygen consumption per kilogram of mass – either the volume of oxygen consumed per kilogram of mass in a time of one second, or to move a distance of 1 metre. The metabolic combustion of 1 millilitre (ml) of O_2 yields about 20 J of energy, so 1 ml O_2/kg/m is equivalent to 20 J/kg/m (Rubenson 2007, Pontzer 2009:49).

quadrupedal vs. bipedal

"**A common image of the evolution**", Roberts 2015:299.

"**Modern chimpanzees and bonobos**", de Waal 1997:25, Lieberman 2010, Sockol 2007, Pontzer 2014. There's no settled view on how our early human ancestors moved around. There is anatomical evidence for our ancestors being adapted for knuckle-walking (Richmond 2001), while others take the view that "*our ancestors were tree-walkers who became ground-walkers*" (Roberts 2015:306, and also Kivell 2009).

"**These modern apes**", Lewin 1999:94 on upright posture, Richmond 2001:99 on upright feeding, and Harcourt-Smith 2007:1484 on locomotion styles.

"**Bonobos are good bipedal walkers**", de Waal 1997:26−27, Pontzer 2014.

"***the expansion of one particular mode***", Roberts 2015:305.

"**For the "average" chimpanzee**", Pontzer 2014, Dunbar 2014a:109, and also Wilkinson 2016:41. I've taken the figure of 6 J/kg/m from Pontzer 2014:figure 1F, which plots the average for five chimpanzees. But figures for costs of transport for chimpanzees vary quite widely. Rodman 1980 gives a figure of 8.5 J/kg/m for quadrupedal motion at 4.5 km/h, while Sockol 2007 gives 3.8 J/kg/m for quadrupedal motion, and 4.2 J/kg/m for bipedal walking at 3.6 km/h. While different researchers may disagree on absolute values for cost of transport, it's well established that there's little difference between the energy costs of quadrupedal and bipedal motion. Also, the large individual variations are real effects, because these appear when using the same experimental methods.

"**In studies of two separate groups**", Sockol 2007, Pontzer 2009 and 2014.

The anatomy of the spines of chimpanzees is surprisingly variable (Lieberman 2013:36 and 45, Pilbeam 2004). There are 4 types of vertebrae in the spines of humans and chimpanzees: from the neck down, they are cervical, thoracic, lumbar, and sacral. Chimpanzees are roughly evenly divided between having 3 and 4 lumbar vertebrae, with a very small number having 5. In contrast, the great majority of humans have 5 lumbar vertebrae, a few have 4, and none have 3 (Pilbeam 2004: tables 1 and 3).

With this amount of anatomical variation, it's not surprising that some chimpanzees walked more efficiently on two limbs than on four. It's reasonable to assume that there was a similar degree of anatomical variation in the earliest hominins, so, as with chimpanzees, there would have been some individuals who walked upright more easily than others.

"**This suggests that the early hominins**", Pontzer 2009.

Being bipedal brings drawbacks, as well as advantages: pregnancy is more difficult; there is a loss of speed, increasing the risk from four-footed predators; and there is reduced agility in trees (Lieberman 2013:46). However, we can infer that the advantages outweighed the drawbacks, for the first hominins "*must have had a slight reproductive advantage from being just partly better at standing or walking upright*" (Lieberman 2013:46).

8.5.2 the second stage: about 4.5−2.5 mya, arboreal and terrestrial – habitual walkers and elective climbers

"**From about 4.5−2.5 million years ago**", I'm lumping *afarensis* and *africanus* together, for they were anatomically very similar, with only minor differences in locomotion (Harcourt-Smith 2007:1500). I'm also lumping together the gracile and robust australopithecines (Lewin 1999:117, Stringer 2011a:126).

"**The australopithecines did not live**", Dunbar 2014a:98, 102 and 114, Harcourt-Smith2007:1508, and Reed 1997:289.

"**The climate continued**", Harcourt-Smith 2007:1508, Plummer 2004:123.

This cooling and drying caused the open woodland and savanna habitats to expand, in which there were fewer fruit trees that were more widely scattered (Lieberman 2013:53). This pushed the australopithecines to forage more widely for lower quality "*fallback foods*", such as leaves, stems and seeds, and also dig for underground foods, like tubers, bulbs and roots (Lieberman 2013:54). Consequently, australopithecines developed large teeth with thick enamel, and large chewing muscles that could be "*the size of small steaks*" (Lieberman 2013:56, and quote from p. 52).

Chimpanzees living in a well-fruited forest are "*surrounded by foods they mostly choose to ignore*", and typically travel 2−3 kilometres a day, mostly going from one fruiting tree to another (Lieberman 2013:60). The australopithecines had to forage over longer distances, and so adapted to become better long-distance walkers (Lieberman 2013:61).

"**Faced with a diversity of habitats**", Potts 1998:117 and 129.

"***there were several different "types" of bipedalism***", Harcourt-Smith 2007:1507.

The australopithecine anatomy

"***an ape-like skeletal design***", Dunbar 2014a:101.

"**The skeleton of *afarensis***", Harcourt-Smith:table 5.1, and also see Lewin 1999:chapter 17.

"***can best be considered***", Harcourt-Smith 2007:1498.

"***bipedality requires a combination***", Harcourt-Smith 2007:1488.

"**These include**", Lewin 1999:106, Lieberman 2004:figure 3, and 2010:figure 3, Stringer 2011a:118, Boyd 2012:221, Dunbar 2014a:101.

"**The Laetoli footprints**", Stringer 2011a:187 and 207, Harcourt-Smith 2007:1493.

"***less competent at complex bipedal behaviours***", Harcourt-Smith 2007:1500, and see also Lewin 1999:116.

"**Chimpanzees live mostly on a diet**", Plummer 2004:122, Lieberman 2010, Stringer 2011a:122.

"**This suite of adaptations**", Lewin 1999:114, Lieberman 2010, Lieberman 2013:51−61.

"***although afarensis was bipedal***" and "***could not achieve***", Lewin 1999:106, and see also Harcourt-Smith 2007:1495 and Stringer 2011a:121, although this conclusion about the restricted walking gait is disputed (Lieberman 2010).

"**These were apes**", Lieberman 2009 and 2010, Lewin 1999:units 19 and 20, Kingdon 2003:chapter 4. *A. afarensis* could well have spent the night in the trees to avoid predators (Harcourt-Smith 2007:1498). Also, the anatomy of *H. erectus* has lost adaptations for climbing, suggesting that facility in climbing was no longer essential (Wrangham 2009:100).

"**The australopithecine anatomy**", Harcourt-Smith 2007:1498.

Daniel Lieberman discusses the ways that the australopithecine anatomy was adapted to enable them for "*long-distance trekking through open habitats*" (Lieberman 2013:60−5, and quote from p. 64).

"**These hominins**", Daniel Lieberman sees the australopithecines as "*a key intermediate stage in human evolution … less arboreal, more habitually bipedal, and less dependent on fruit, setting the stage for subsequent evolution occasioned by yet more climate change*" (Lieberman 2013:66).

reducing the energy cost of walking

"**We've seen that the walking energy cost**", the experimental measurements aren't very consistent. An early study puts the human walking energy value at 3.4 J/kg/m (Rodman 1980), but the average of many studies gives values of 1.7 - 2.6 J/kg/m, with a mean of 2 J/kg/m (Rubenson 2007). But Sockol 2007 measured bipedal values of about 1 J/kg/m for modern humans and about 4 J/kg/m for chimpanzees, using the same experimental procedure. While different researchers come up with different energy values, there seems to be agreement that that the bipedal energy cost for humans is about 25−30% of the value for chimpanzees.

"**The low energy cost of human walking**", Carrier 1984, and Bramble 2004.

"***an inverted swinging pendulum***", Carrier 1984:485.

"**We can't measure**", Pontzer 2009:figure 4. Pontzer estimates the CoT figures (in J/kg/m) as: 4.6 for a bipedal chimpanzee, 3.6 for a quadrupedal chimpanzee, and 1.8 for a bipedal human, and the figure for *afarensis* at between 4 and 2 J/kg/m, depending on whereabouts the australopithecine anatomy lay between the chimpanzee and human extremes.

extended foraging and time budgets

"**All social apes have a time budget**", the general principles of time budgeting are in Dunbar 2014a:84−93, and time budgets for australopithecines are in Dunbar 2014a:102−126.

"**There must be time**", Dunbar 2014a:84 and figure 3.6.

"**The time budget model**", Dunbar 2014a:122.

"**It appears that the australopithecines**", Dunbar 2014a:116, Wrangham 2009:116, deMenocal 2004.

sweating, lice and body hair

"**A lifestyle that involves spending time**", an upright posture reduces the area of the body exposed to the tropical sun, and it's been argued that this was an important factor in the evolution of bipedalism (Dunbar 2014a:111). But the reduction in exposure is greatest when the sun is high in the sky, and this is the time when the hominins would have been resting. Hominins would have been travelling near the start and the end of the day, when the sun is lower in the sky, and an upright posture only slightly reduces the exposure at these times.

"**However, sweating**", Dunbar 2014a:112.

"**Gorillas, chimpanzees and humans**", Reed 2007, Weiss 2009.

sharing food – the start of inter-dependence?

"**With feeding being dependent**", de Waal 1997:135 considers this sort of situation. Individuals are more at risk from predators when on the ground than in the trees, and it would be females with dependent young who would be most at risk. So, one can imagine a scenario where males protect females and their young, and also go foraging and walk upright to bring food back. Frans de Waal considers that neither the female-centred bonobo social structure, nor the independent lifestyle of male chimpanzees would have coped with a lifestyle in which females and young were dependent on male assistance and protection. Our human ancestors are the only hominids who "*managed to abandon the safety of the trees altogether*" (de Waal 1997:136). It may be that this is the basis for the nuclear family, a feature unique to humans.

"***the males were probably less arboreal***", quote from Stern 1983, and also see Harcourt-Smith 2007:1508, and Stringer 2011a:121.

"**Next, the regular sharing of food**", Dunbar 2017c.

"**So, the experiences of early hominins**", Michael Tomasello has proposed that human cooperation started with early hominins, who had to become inter-dependent "collaborative foragers" to survive (Tomasello 2012). Individuals became "*inter-dependent with one another for subsistence, which led naturally to helping those on whom one was dependent. This required the development of cognitive skills for putting one's head together with others in acts of mutualistic collaboration and communication*" (Tomasello 2012:685).

8.5.3 the third stage: from about 2.5 mya, fully terrestrial – obligate walking and elective running

introducing the genus Homo

"**As the hominin body plan**", Bramble 2004, Lieberman 2009a and 2009b.

"**First came early *Homo***", for early *Homo* see Harcourt-Smith 2007:1503 and Lewin 1999:119. I've lumped together *H. habilis* and *H. rudolfensis*, which are very similar, with the latter appearing slightly more modern than the former (Lewin 1999:124). I'm also lumping together *H. ergaster* with the major species that followed it, *H. erectus*, (Lewin 1999:unit 24, Dunbar 2014a:10). While there are early skeletons of *erectus* in the Caucasus, dating from about 1.8 mya, it's generally accepted that *erectus* originated in Africa about 1.9 mya (Stringer 2011a:139).

"***H. erectus* is now regarded**", Dunbar 2014a:10 and 141.

"***H. ergaster* and *H. erectus* appeared**", Lewin 1999:chapter 24.

"**The new features include**", Lewin 1999:chapter 24, Leakey 1994:chapter3, McHenry 2000, Kingdon 2003:chapter8, Wrangham 2009:chapter 4, Bramble 2004, Lieberman 2009b.

“***H. erectus* stands**”, The transformation of bodyplan from chimpanzee through *afarensis* and then *africanus* to *ergaster* to modern human is shown strikingly in Kingdon 2003:figure 8.4.

“***at a pivotal point***”, Leakey 1993:46.

“**This body shape is optimal**”, Stringer 2011a:139, Potts 1998:119.

“***Homo species appear the first***”, Reed 1997:289.

“**If *erectus* hominins**”, Daniel Lieberman sees *H. erectus* as “*the first ancestor we can characterize as significantly human*” (Lieberman 2013:72).

“***time-traveled to a modern city***”, Wrangham 2009:5.

adaptations for running

“**In contrast, the running gait**”, Lieberman 2007a:289.

“***somewhat like a controlled fall***”, Lieberman 2009a:79.

“**The asymmetric leg movements**”, Bramble 2004.

“**So, running requires specific adaptations**”, Bramble 2004, Lieberman 2007a and 2013:85−8, and Wilson 1975:547 also gives a list of anatomical features.

“**All of these adaptations**”, Bramble 2004, Plummer 2004:128.

“**This suggests that some time**”, Harcourt-Smith 2007:1501.

“***H. erectus* could still climb trees**”, Wrangham 2009:98.

the energy cost of running

“**The energy cost for human walking**”, Cavagna 1977, Rubenson 2007.

“**However, if you switch to a running gait**”, Pugh 1970, Cavagna 1977, Rubenson 2007, and Bramble 2004 all state that the energy cost for a running human is about 4 J/kg/m, and that it does not vary with running speed. However, Steudel-Numbers reports that the running energy cost varies with speed, with a minimum value of about 4 J/kg/m at a speed of around 12 km/h (Steudel-Numbers 2009, and the average energy cost is calculated from the graphs in figure 1).

sweating and endurance running

“**But humans can lose**”, Carrier 1984.

“***specialised sweaters***”, Lieberman 2007a.

“***This fits well with the genetic studies***”, Reed 2007, Weiss 2009.

scavenging and persistence hunting

“**These increases required**”, Dunbar 2014a:145−149. Brain tissue requires a lot of energy to function, so that in a modern human the brain takes about 1/5th of the total nutrition intake. A 100% increase in brain size is equivalent to 100/5 = 20% increase in body mass, so the total increase in effective body mass of *H. erectus* is about 40+20 = 60%. The nutrition energy required to operate the body scales as body mass$^{0.75}$, which is the body mass raised to the power 0.75 (as 100 is 10 raised to the power 2). So, a 60% increase in body mass requires an increase in nutrition of about $60^{0.75}$ = 22%, most of which is needed for the increase in body size (Dunbar 2014a:146 and 387). This calculation is simplified, but still shows clearly that the *erectus* body and brain sizes can’t be sustained by the australopithecine lifestyle.

“**Quadrupedal cursorial species**”, the energy cost for running quadrupeds varies with species, but it follows a general trend of decreasing with increasing body mass: for a hunting dog it’s about 6 J/kg/m, for a 50 kg elk calf it’s about 4 J/kg/m, and for a pony or a horse it’s about 2 J/kg/m (figures for ponies from Bramble 2004, and for other quadrupeds from Rubenson 2007).

“**These species can travel**”, a cheetah can out-sprint all other prey species, but its body temperature rises rapidly as a result of the heat generated, and it rarely runs more than 1 km. It appears that the duration of the cheetah’s sprint is limited not by fatigue, but by over-heating (Carrier 1984).

“**In long-distance travel**”, Lieberman 2007a.

“**The major limiting factors**”, Carrier 1984, Bramble 2004.

“***can outrun almost all other mammals***”, Bramble 2004, Lieberman 2007a.

“**Grassland is a poorer source**”, Leonard 1997:277, Plummer 2004:124. Grassland is about half as productive as forest for primary plant nutrition, but about three times as productive in secondary herbivore meat. For a standard amount of 100 g, leaves provide about 40−80 kJ, fruits provide about 200−400 kJ and meat provides about 400−800 kJ (Leonard 1997:277).

“**They could practise persistence hunting**”, Lieberman 2007a, 2009a:84 and 2010, Liebenberg 2006.

“**If hunting was not possible**”, Lewin 1999:chapter 26, Lieberman 2007a, 2007b, 2009a.

“**By about 2½ million years ago**”, Lieberman 2007a.

8.6 the evolution of cognition

Figure 8.14 is based on Lewin 1999:191, and Bonner 2006:figure 16, using McHenry 2000:137 for hominid data, Grabowski 2015 for hominin body masses, and Dunbar 2014a:figure 1.3 for hominin brain volumes. Representative values for body masses and brain sizes for hominins, current *Homo* and primates all vary considerably. Ranges for current primates are: bonobos, 275−380 cc, chimpanzees, 280−450 cc, and for gorillas, 350−750 cc (Schoenemann 2013:154). I’ve used Molina’s figure of 1,320 cc for current humans (Molina 2012, 2015). I’ve used body mass values from a recent study, which found that many hominins were smaller than previous investigators had thought (Grabowski 2015). The plot in figure 8.14 is very similar to Lewin’s plot (Lewin 1999:191), just shifted to lower body masses. Grabowski shows that all hominin species show a wide range of body masses, just as de Miguel 2001 shows a wide range in fossil brain sizes. Grabowski’s values should be self-consistent, and they clearly show the hominin species breaking out dramatically from the allometric pattern of the great apes.

Robin Dunbar considers that there is a linear relation between mentalising level and brain size (Dunbar 2014a:figure 2.4), but I’m being cautious about this.

“***what features of the environment***”, and “***once started***”, Wilson 1975:566.

8.6.1 bones and stones – indicators of a carnivorous lifestyle

"**Around 2½ million years ago**", Potts 1991, Lewin 1999:unit 23, de Heinzelin 1999, Schick 1995 and 2006, de la Torre 2004, Delagnes 2005, Semaw 2000 and 2006, Roche 2009, Toth 2018. It seems to be generally accepted that the first use of stone tools dates from around 2.6 mya, but these tools are fairly sophisticated. Stone knapping requires considerable skill, which would have taken some time to develop, and so there must have been some shaping of stone before 2.6 mya, but the artefacts are so crude that they are hard to find. However, cut-marks from stone tools have been found on bones dating from about 3.4 mya, and attributed to *A. afarensis* (McPherron 2010, Toth 2018:5). No stone artefacts were found with the bones, so we don't know how the tools were made.

"**The earliest stone tools**", de la Torre 2004.

"**These tools are known as Oldowan**", de la Torre 2004, Semaw 2006:43, and see Potts 1991:164. Oldowan tools are named after the Olduvai gorge, also called the Oldoway gorge, where they were first discovered.

"**It's uncertain whether**", Lewin 1999:134, Schick 1995:102 and 2006:18, Plummer 2004:125, Semaw 2006:69. Plummer 2004 is a thorough and comprehensive review of Oldowan hominins.

"**Whoever were the first tool makers**", Lewin 1999:chapters 25 and 30.

"**Oldowan tools are simple**", Potts 1991, Lewin 1999:unit 23, Schick 1995:chapter 3 and 2006, Toth 2018.

"**It appears that it was the flakes**", Delagnes 2005, Schick 2006:18 and 26, Toth 2018:17.

"**Reconstructions have shown**", Potts 1991:163, Delagnes 2005.

"**Even the simple Oldowan tools**", Schick 1995:57 and 135, and 2006:24, Toth 2006, and 2018:12.

"**Chimpanzees in the wild**", Toth 2007:1947.

"**The East African environment**", Plummer 2004:122.

"**The majority of Oldowan sites**", Plummer 2004:124, Schick 2006:10, Toth 2018:8.

"**Tools were made**", Schick 1995:122 and 2006:9 and 29, de la Torre 2004.

"**Experiments with stones**", Braun 2009:1610.

"**Hominins selected rock**", Braun 2009:1611.

"***the great majority***", Schick 2006:25.

"**They were selective**", de Heinzelin 1999, Semaw 2000 and 2003, de la Torre 2004, Schick 2006, Toth 2018:14.

"***four meat or butchering knives***", Keeley in Schick 2006:19.

"**Several studies**", Lemorini 2014, Plummer 2016:35, Boyd 2012:figure 11.12.

"**This suggests that the Oldowan hominins**", Boyd 2012:250.

"**When hunting, chimpanzees limit themselves**", chimpanzees hunt woodland species, mainly colobus monkeys, and they are very reluctant to scavenge from carcasses killed by other carnivores (Plummer 2004:141).

"**In marked contrast**", de Heinzelin 1999, Semaw 2003, Plummer 2004:130 and 147, Schick 2006:10, 19 and 34.

"***unequivocally that the earliest artifacts***", Semaw 2006:43.

"**It's worth bearing in mind**", Pickering 2006:123.

"**Some archaeologists**", Schick 1995:chapter 5.

"***were amazed***", Schick 1995:168.

"***with a simple flake***", Schick 1995:169.

hominins have their own tapeworm species

"**Additional evidence**", Hoberg 2001 and 2006, Boyd 2012:276. There is further evidence of hominins' diet shifting to take in more meat from grazing savannah herbivores from the chemical analysis of the balance of carbon isotopes in their teeth (Dunbar 2014a:117).

"**Modern humans**", Hoberg 2001:781 and 785, and Hoberg 2006:S26 and figure 1.

scavenging or hunting?

"**In passive scavenging**", Plummer 2004:142, Parkinson 2018:45.

"**In active scavenging**", also called confrontational or power scavenging.

"**It's difficult to distinguish**", Plummer 2004:144, Roche 2009:141.

"**Sites in the Olduvai Gorge**", Plummer 2004:141, Pickering 2006, Roche 2009, Parkinson 2018.

"**These Olduvai sites**", Plummer 2004:141–143, and tables 5 and 6 and also Roche 2009:140. These are from Olduvai Bed I, which dates from about 1.8 mya (Plummer 2004:121). One 2 million-year-old site in Kanjera South, a little way from Olduvai, has yielded complete skeletons of small immature antelopes, bearing damage from stone tools, and this suggests that hominins acquired these by hunting rather than scavenging. Bones of larger grazing animals appeared to be scavenged, either by passive or active scavenging (Plummer 2016).

"**Carcasses of mammals of this size**", Plummer 2004:152.

"**Most, possibly all, of the animal bones**", Plummer 2004:144.

"**The remains of small, immature carnivores**", Plummer 2004:140 and 144.

"**A number of lines of evidence**", Parkinson 2018:47.

"**First, carnivores tend**", Parkinson 2018:47.

"**Second, the bones**", Parkinson 2018:46.

"**Finally, the patterns**", Parkinson 2018:45.

"**Many sites yield bones**", Plummer 2004:145.

"**The patterns of cut-marks**", Plummer 2004:145, Pickering 2006:122.

"**The larger mammals**", Parkinson 2018:47.

"***often had access***", Plummer 2004:146.

"**In this the hominins are like**", Lewin 1999:152, Leakey 1994:72, Boyd 2012:263.

"***not an occupation***", Boyd 2012:262.

"**To ask whether the Oldowan hominins**", Lewin 1999:152. There has been a lot of effort put in to answering this question, and it possibly stems from the view that it is unflattering to think of our ancestors as scavengers, and that a scavenger lifestyle is "*far from the Man the Noble Hunter image of traditional theory*" (Leakey 1994:72). Roche sees the dichotomy of the hunting vs. scavenging debate as an "*oversimplification that does justice neither to the evidence, nor to the behavioral variability*" of hominins (Roche 2009:137).

8.6.2 the cognitive abilities of the Oldowan hominins

2nd level mentalising enables imagining complex, shared tasks

a behavioural test for theory of mind

joining the carnivore guild

"**The early Oldowan hominins**", Roche 2009:136.

"***to be a carnivore***", Lieberman 2007a:290.

"**So, around 2½ million years ago**", Lieberman 2009a:83, Roche 2009:136.

"***hominins possessed the capability***", Pickering 2006:122.

"***cooperation and cunning***", Stringer 2011:109.

"**For example, a large pack of hyenas**", Plummer 2004:139 on hyenas, and Cheney 2007:47 on baboons.

"***a unified, sophisticated predatory 'organism'***", Whiten 2012:2122.

the manual and mental skills involved in tool-making

"**The early Oldowan tools**", Schick 1995:118 and 122, Delagnes 2005.

"***efficient flaking of stone***", Schick 1995:133.

"***turned the core***", Schick 1995:96.

"**The early Oldowan tool-makers**", Delagnes 2005.

"***carry an air***", Lewin 1999:131.

"***overlap and continuum of form***", Potts 1991:161.

right-handed hominins

"**But making a stone tool**", Schick 1995:140.

"**Experiments in recreating Oldowan tools**", Schick 1995:142, Boyd 2012, figure 11.3.

extended childhood and learning

"**Modern human infants**", Leakey 1994:46, Lewin 1999:143.

Christopher Wills sums it up in this way: "*The human brain does most of its developing outside the womb, but the chimpanzee brain develops primarily within it*". Consequently, most of the development of a human brain comes from being "*bombarded with stimuli from the outside world, stimuli that are largely denied to the developing brain of a chimpanzee*" (both quotes from Wills 1994:6). As our hominin ancestors evolved, the balance of their brain development shifted from inside the womb to the outside world, and this opened up more opportunities for further brain evolution.

"**Experiments in stone knapping**", Schick 1995:chapter 4, Stout 2006, Toth 2018.

"***suggests the presence***", Stout 2006.

"***strong selection pressure***", Roche 2009:142.

the logistics of supply of stone tools

"**Chimpanzees use stones**", Goodall 1986:544, Schick 1995:57.

"**The Oldowan hominins**", stone tools and processed bones are found together in many Oldowan sites, and many investigators have tried to infer hominin lifestyles from the fossil evidence at these sites. Many hypotheses have been put forward, and there appears to be no consensus on how the sites were used (Lewin 1999:chapter 26, Plummer 2004:133, and Schick 2006:20 outline different models). I'm concerned with the factors that caused hominin brains to get bigger, and I don't think that considering these different lifestyle hypotheses will help.

One of the hypotheses proposed that stones in both raw and partly processed states were cached at certain sites (sometimes called manuports) ready for future use (Potts 1991, Plummer 2004:134). Further investigation proposed that many caches were the result of natural processes, but accepted that some had been accumulated intentionally, and were genuine manuports (de la Torre 2005).

"***two spatially separate resources***", Potts 1991:170.

"***Oldowan sites***" and "***tool-makers***", Potts 1991:163.

"**In the early Oldowan**", Schick 1995:128, Plummer 2004:132 and 2016:34, Roche 2009, Toth 2018:15. Hominins were transporting stone from the earliest Oldowan times, around 2.6 mya (de Heinzelin 1999, Semaw 2000 and 2003).

"**The logistics**", Potts 1991:161, Schick 1995:128, Plummer 2004:132 and 2016:34, Toth 2018:15.

"**Cobbles were often partly flaked**", why did the Oldowan hominins do things this way? The accounts given by Potts 1991:161, Schick 1995:128, and Plummer 2004:132 and 2016:34 suggest some simple inferences. The most difficult step in stone-knapping is the production of the first flakes, and these are sometimes produced by pounding one cobble with another to produce an acute edge from which flakes can be detached in a more controlled way. Breaking open a cobble would give some indication of its internal quality, and whether it would produce a series of good flakes. These two observations indicate that the initial flaking of cobbles at their source would be a useful practice (Schick 2006:27, Toth 2006:215). Thereafter the partly flaked core could be carried as one unit to the butchery site, and flakes produced from it as they were needed (Schick 1995:169). Partly flaked cores would then be taken from one site to another, if they could still provide further flakes.

"***it was the spatial pattern***", Potts 1991:153.

"***were moved around***", Plummer 2016:30.

division of labour in the Oldowan social economy

"**So, we can infer**", Wrangham 2009:chapter 6, Lieberman 2009b:11, Plummer 2004:152.

"***hunting and extractive foraging***", Boyd 2012:252.

"**This division of labour**", Boyd 2012:253.

"**Both extractive foraging and hunting**", Boyd 2012:figure 11.10.

“**The hominin group depended**”, Plummer 2004:152, Lieberman 2009a:87.

In Daniel Lieberman’s view, “*the first hunter-gatherers would have benefited so strongly from sharing food that it is hard to imagine how they could have survived without both females and males provisioning each other and cooperating in other ways*” Lieberman 2013:75).

He sees the division of labour coinciding with the development of a lifestyle of hunting and meat-eating (Lieberman 2013:74). But mutual dependence is the basis for the division of labour, and this must have started earlier (see section 8.5.2: sharing food – the start of mutual dependence).

Oldowan hominins had passed the theory of mind threshold

“**Thus they pass the behavioural test**”, and we can go further and use the list of social behaviours that Simon Baron-Cohen regards as depending on theory of mind (Baron-Cohen 2000:262). These are:

1) intentionally communicating with others – to change the knowledge state of the listener
2) repairing failed communication with others – such as, checking that the listener has understood
3) teaching others – to change the knowledge state of the listener
4) intentionally persuading others – to change someone’s belief about the value of something
5) intentionally deceiving others – to place false information, or a false belief, in the mind of another
6) building shared plans and goals – to combine individual actions to achieve a goal that is not possible alone
7) intentionally sharing a focus or topic of attention – so that each is aware of the other’s attention to the same object
8) pretending – to treat one object as if it’s something else, with a different “pretend” identity

Three important features of the Oldowan lifestyle are: membership of the carnivore guild, the logistics of tool production and distribution, and making individual stone tools. The first two features depend on social behaviours 1, 2, 4, 6 and 7, and the third depends on behaviours 1−3. So, it seems clear that the Oldowan hominins had cleared the theory of mind threshold, and were operating at the 2nd mentalising level in a number of respects. See also the earlier note to section 8.2.1.

“***biological adaptation was overtaken***”, Kingdon 2003:276. The Oldowan hominins are sometimes described as inhabiting a “*socio-cognitive niche*”, where “*many more resources become available by the ability to perform appropriate learned or invented manipulations*” (Tooby 1987:209, Whiten 2012). An organism’s habitat is its “address”, but its niche is its “profession” – how it supports itself in the ecosystem (Campbell 2008:1199). Niches are competitively exclusive, and two species can’t coexist permanently if their niches are identical, which makes a niche look like the biological equivalent of a set of quantum numbers (such as the quantum numbers that define electron orbitals in atoms – see the notes to sections 3.6.2 and 5.7.5).

“**Robin Dunbar has correlated**”, Dunbar 2014a:figure 7.4 and 2020:figure 4, and see the notes following figure 8.13.

“**Clive Gamble regards features**”, Gamble 2011.

Daniel Lieberman sees a hunter-gatherer lifestyle as being dependent on “*intense cooperation*”, which requires “*complex cognitive skills beyond those of apes. To cooperate effectively one needs a good theory of mind (to intuit what another person is thinking)*”. So, it is “*not coincidental that major increases in brain size occurred after the origins of hunting and gathering*” (all quotes from Lieberman 2013:92).

crossing the theory of mind threshold

8.6.3 going beyond theory of mind to higher levels of mentalising

“**If theory of mind**”, one view of this is that a positive feedback loop came into play, which drove brain enlargement (Lieberman 2013:121).

The basic idea is that once an individual has taken care of their own body’s basic needs, any surplus energy can be “spent” in four different ways: (1) to grow further, if they are young; (2) to store as fat; (3) to be more physically active; or (4) to raise more offspring. The Oldowan hominins would benefit by investing their surplus energy in “*fewer, better-quality offspring by extending their development so they can grow larger brains*” (Lieberman 2013:121). These bigger-brained offspring would be capable of learning more complex cognitive and social behaviours, and so become better hunter-gatherers, who will generate even bigger surpluses of energy and resources.

This section outlines some plausible selection pressures that would favour the evolution of hominins’ cognitive abilities beyond basic theory of mind.

the cognitive demands of hunting

“***an intensely social activity***”, Sterelny 2007:725.

“**Thus, there is an evolutionary selection pressure**”, considering modern hunter/gatherer societies, Andrew Whiten suggests that hunting success rests on “*each hunter utilizing a model of his co-hunters’ psychology, including states of mind*”, such as “*desires, intentions, ignorance, knowledge and belief. This suggests that selection pressures were active with respect to mind-reading*” (Whiten 2000:188). However, we’ll see that the cognitive demands of group hunting would drive mentalising beyond theory of mind, or 2nd level mentalising.

“***competent others***” and “***mutual expectations***”, Gruneisen 2015:288.

Alice and Bob go hunting

Figure 8.15 gives a comprehensive view of the gazelle hunt, and includes both Alice and Bob, and depicts their mentalising processes in three ways: visually, verbally and as strings of initial letters, to cater for different styles of thinking.

Alice’s thoughts about Bob

the selection pressure for higher levels of mentalising – the cull of the dull

“**We can’t be sure**”, in modern hunting/foraging groups, men take responsibility for hunting and women take responsibility for foraging (Boyd 2012:252).

“***hunting is always dangerous***”, Tudge 1996:200.

mentalising and mediation

“**Frans de Waal has estimated**”, de Waal (2007:178) gives the following figures: male-male conflict every 5 hours (meaning about 5/day); male-female conflict every 13 hours (about 2/day); and female-female conflict every 100 hours (about one every four days). He suggests that the reason females have far fewer fights than males is “*probably because they work hard to avoid them*” (de Waal 2006:150). While males have many more disputes, about half of them end in a reconciliation, whereas for females the figure is about one in five (de Waal 2006:150). For bonobos, females reconcile far more readily, and males much less so.

“**It’s only females**”, de Waal 2006:157−159.

“***allows male rivals***”, de Waal 2006:158.

“***no male would ignore her***”, de Waal 2006:158.

“***All the females obeyed her***”, de Waal 2006:79.

“***the entire community***”, de Waal 1989:26.

fire and cooking

“***biologically committed***”, Wrangham 2012.

“***adapted to eating***”, Wrangham 2009:14.

“**Very few humans**”, Wrangham 2009:chapter 1, and 2012.

“**There is direct evidence**”, Wrangham 2009:85−88, Wrangham 2012, Gowlett 2016.

There is unambiguous evidence, in the form of burned bones and plants, of the use of fire in caves in South Africa around 1 million years ago (Berna 2012).

“**The evidence implies**”, Rowlett 2000:198, Schick 2006:23, Gowlett 2013:23, Toth 2018:26.

“**Natural fires, caused by lightning**”, Gowlett 2016.

“**Modern savannah chimpanzees**”, Pruetz 2010.

“**Natural fires enable fire foraging**”, Gowlett 2012:705 and 2016.

“**These casual fires**”, Gowlett 2016.

“**The physical evidence**”, Wrangham 2009:88, Gowlett 2012:704.

“**Cooked food**”, Wrangham 2009:chapter 3, and 2012.

“**They would need less time**“, this is the “expensive tissue hypothesis” (Wrangham 2009:112, Schick 2006:23). Neurons need a lot of energy in the form of glucose in order to operate. Nerve tissue requires about 10 times the energy input as normal body tissue, so the average human brain requires about 20% of the body’s total food energy intake, even though it is only about 2 % of the total body weight, so that overall, “*every fifth meal is eaten solely to power the brain*” (Wrangham 2009:109). But the gut also requires a lot of energy to function, because it is “*churning, making stomach acid, synthesizing digestive enzymes, or actively transporting digested molecules across the gut wall and into the blood*” (Wrangham 2009:112). An improvement in diet, which reduced the burden on the gut, would make an energy saving that could be used to sustain a larger brain. Wrangham 2009:chapter 5 explains how the enlarging hominin brain can be enabled by an improving diet.

“**The transition**”, Wrangham 2009:96.

For non-human primates, the time spent feeding loosely correlates with body mass and tooth size (Organ 2011). If humans fed themselves like these primates, then we would spend about 50% of the day feeding. But we spend only about 5% of the day feeding, and this shows us to be clear evolutionary outliers in terms of feeding time. Trends in body mass and molar size in human ancestors and non-human primates have been taken as supporting the idea that hominins started cooking food around the time that *H*. *erectus* appeared, which was about 1.9 million years ago (Organ 2011, and see back to figure 8.13).

“**The adaptations for running**”, Wrangham 2009:99.

“**It might be that our human ancestors**”, Wrangham 2009:102 and 2012:190.

“**Meat is more nutritious**”, Lieberman 2009b:12.

“**For example, a chimpanzee can take an hour**”, Wrangham 2009:118.

“**Chimpanzees need to spend**”, Wrangham 2009:142−144, Lieberman 2009b:11, and Lieberman 2013:48.

So, to get enough nutrition from a wholly fruit diet, a chimpanzee will consume about 1 kilogram of fruit in an hour, then wait for about 2 hours for this to be digested, so that its stomach becomes empty, and it can feed again (Lieberman 2013:48).

“**This disparity is wholly down to cooking**”, Wrangham 2009:139−142. In experiments in which chimpanzees and other apes were offered the choice of raw or cooked food, no apes preferred any food raw, and preferred their carrots, potatoes and meat to be cooked. Even chimpanzees of the Tchimpounga population, who had no experience of eating meat, strongly preferred cooked meat over raw meat (Wrangham 2009:90).

“**Cooking would solve this problem**”, Wrangham 2009:138 and 142.

“**Furthermore, the fire that was used**”, Wrangham 2009:146.

fire and socialising

“**It brings an increased demand**”, Gowlett 2012:705.

“**Fire provides protection**”, Dunbar 2014a:228, 2014b.

“**This would open up possibilities for social interactions**”, Wiessner 2014.

“**… once the subsistence needs …**”, Dunbar 2014b, Wiessner 2014.

“**This would ease the constraints**”, Dunbar 2014a:228.

“***time structures interactions***”, Wiessner 2014:14027.

“**Communal eating**“,Dunbar 2014a:195, and 2017c.

“**Evenings around a fire**“,Dunbar 2014a:208 and 227, 2014b.

“***charismatic storytellers***”, Dunbar 2014b:14014.

mentalising and storytelling – a shared imagined world

“***the capacity to understand***”, Dunbar 2020:55.

“***decoupling of mental representation and reality***”, Sommer 2007:5.

“***to step back far enough***”, Gamble 2011:117.

“**With theory of mind**”, with theory of mind we comprehend we each have a limited perspective on reality, and so there may be a greater reality, that is bigger than any of us can perceive. From this it’s only a small step to imagining an all-seeing creator, who lives in another world, and who understands all perspectives (Dunbar 2020).

“***the composition of a modern novel***”, Dunbar 1998b:102, the levels of mentalising have been added in square brackets.

“***the eternal triangle of relationships***”, Dunbar 1998b:102.

"**As an example of this**", Dunbar 2004:120 and 162.

"**Robin Dunbar makes the point**", Dunbar 2004:162.

Figure 8.18 is based on Dunbar 2004:120 and 162.

8.6.4 a review of the scale of mentalising

8.7 a community of minds

is 5th level mentalising the end of the line?

an optimal level of mentalising

"***an optimal level of intelligence***", Barrow 2008:chapter 87.

"***evolutionary 'ratchet'***", "***general intellectual standing***" and "***intelligence itself becomes a burden***", Humphrey 1984:22.

"**Every event**", we've seen that over our 6 million years evolution, our ancestors have become adapted for a number of things – to walk upright, to be endurance athletes and hunters, to cook food, and to develop higher mentalising skills.

But Daniel Lieberman points out that the special adaptation of modern humans is, "*our ability to be adaptable because of our extraordinary capacity to communicate, cooperate, think, and invent*" – that is, we have become adapted for culture. "*The pace and scope of cultural evolution now vastly exceeds the pace and scope of biological evolution*" (Lieberman 2013:149 and 150).

This chapter has described how our ancestors attained theory of mind, and has outlined the drivers for their further cognitive development. For an account of humanity's physical evolution to the present day, see Lieberman 2013, and for an account of our cultural evolution, based on shared belief in imagined social orders, otherwise known as history, see Harari 2015.

"**The connections are mediated**", Crystal 2010.

"***reliably cause precise new combinations of ideas***", Pinker 1995:1.

"***collectivism of thought***", Tudge 1996:260.

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"***the local embodiment of a Cosmos***", Sagan 1981:345.

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