

6-23-2011

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Recommended Citation

Booth, Laura (2010) "An Evaluation of *Homo habilis sensu lato* Variability Through a Comparative Analysis of the Coefficient of Variation of Three Hominid Species," *Totem: The University of Western Ontario Journal of Anthropology*: Vol. 18: Iss. 1, Article 14.
Available at: <http://ir.lib.uwo.ca/totem/vol18/iss1/14>

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Keywords

Homo habilis sensu lato, variability, cranial capacity

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**An Evaluation of *Homo habilis sensu lato* Variability
Through a Comparative Analysis of the Coefficient of Variation of Three Hominid Species**

Laura Booth

*The fragmentary nature of the fossil record leaves palaeontologists with the difficult task of sorting through the morphological variation found in fossil hominins in order to assign recovered specimens to the best suited species classification. Controversy arises in assessing the acceptable degree and pattern of variation allowed for within a single species. This lack of agreement concerning how much variability can be subsumed within a single species is at the core of the debate surrounding the identity of the taxon *Homo habilis*. To assess the number of taxa present within the *H. habilis* hypodigm, the coefficient of variation (CV) of cranial capacity was calculated for a sample of *H. habilis* specimens, six modern *H. sapiens* populations, and two *Pan troglodytes* skeletal collections. The results showed that *H. habilis sensu lato* has a CV value much greater than that calculated for human or chimpanzee populations, indicating that a single species solution for interpreting the *H. habilis* hypodigm maybe unsupported. Rather, it suggests that the *H. habilis* hypodigm represents at least two distinct species of early *Homo*.*

It is no secret that issues of variability in the fossil record plague hominin paleoanthropology. Moreover, fossils are not amenable to classification based on the biological species concept, as it requires living individuals to test reproductive capabilities. As a result, paleoanthropologists must assign hominin fossils into distinct species using variation in morphological, ecological, temporal, spatial, etc. characteristics. However, the fragmentation both temporally and spatially of the hominin fossil record makes identifying species difficult. Without a large and intact hypodigm it is difficult to determine if two fossil specimens possessing different morphological traits represent two distinct species or rather represent opposite ends on a variability continuum of a single species. Classification becomes even more difficult when these specimens are found to coincide geographically and/or temporally. While it may be a complicated task to definitively classify finds, species are the fundamental unit of paleoanthropological analysis (Tattersall 1992) and, as a result, researchers will attempt to reach some sort of consensus on how to assign specimens to particular taxa. Two major approaches to interpreting the variability in the fossil record have emerged: an anagenetic paradigm, and a cladogenetic paradigm.

Briefly, the anagenetic approach takes the perspective that hominins appear to be a single, gradually evolving lineage and thus fossil hominin specimens should be subsumed into very few species (Henneberg and de Miguel 2004). However, cladogenetic approaches interpret variability as

indicating the existence of multiple species. From this perspective, hominins are a diverse and speciose lineage (Foley 1991; Tattersall 1992).

Adding to the confusion of classifying extinct species, the terminology used in grouping different ape genera often carries variable definitions. In this paper, hominin refers only to species within the *Homo* clade. Hominid refers to *Pan*, *Gorilla*, and *Homo* while hominoid refers to *Pan*, *Gorilla*, *Pongo*, and *Homo*.

The controversy over identifying hominin species centers on determining the acceptable degree and pattern of variation allowed within a single species. It is interpreting this variability that is at the core of a long-standing debate surrounding the *Homo habilis* hypodigm. Paleoanthropologists disagree on the number of species that are represented by *H. habilis sensu lato*. The *H. habilis* hypodigm consists of a group of smaller-brained, small-toothed individuals, as well a group of larger-brained individuals with large teeth, relatively long faces, less prognathism, and reduced supraorbital tori (Rightmire 1993). While some researchers assert that *H. habilis* is a single and morphologically highly variable species (Miller 1991; Hunt 2003), others maintain that these fossil specimens represent at least two distinct species of early *Homo* (Rightmire 1993; Kramer et al. 1995; Lieberman et al. 1996).

This paper argues that a comparison of the coefficient of variation (CV) of the cranial capacities of *H. habilis*, modern *H. sapiens*, and *Pan troglodytes* does not support a model for a single species of *H.*

TOTEM: vol. 18 2009-2010

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habilis. Rather, the degree of variation in the cranial capacities of *H. habilis sensu lato* suggests the presence of multiple species within the hypodigm. Admittedly, cranial capacity is only one measurement of variation and other features must be considered before making any definitive conclusions about the number of species represented within *H. habilis sensu lato* (see conclusion). Indeed, a comparison of several features will always lead to more highly supported conclusions. However, comparing cranial variation does substantially contribute to the debate regarding the *H. habilis* hypodigm.

Solutions for Interpreting Variability in *H. Habilis sensu lato*

As stated, researchers offer two solutions to interpreting the variability in *H. habilis sensu lato*: single species or multiple species. Interestingly, although these two hypotheses are mutually exclusive, both solutions examine the same lines of evidence to support their models. Single species proponents and multiple species proponents both attempt to determine whether or not the degree of variation in *H. habilis sensu lato* is within the range of variation of extant hominid species and both sides examine the possibility that sexual dimorphism explains the degree of variation within *H. habilis*. However, their conclusions about variability are vastly different.

Single Species Solution

Researchers who argue that *H. habilis* represents a single species view the observed variability as being intraspecific. That is, single species proponents argue that the variability of cranial capacity and tooth size within the *H. habilis* hypodigm fits within the range of variability observed in extant hominid species, the most often cited being gorillas and orangutans (Miller 1991). Further, the single species solution asserts that *H. habilis* exhibits differing craniodental morphology because the species was extremely sexually dimorphic with the larger-brained specimens being male and the smaller being female (Rightmire 1993).

Multiple Species Solution

Proponents of the multiple species solution argue that the *H. habilis* hypodigm represents at least two distinct species. This separation is often

made between *H. habilis sensu stricto* as the smaller-brained specimens and *H. rudolfensis* as the larger-brained individuals (Lieberman et al. 1996). In this sense the observed variation is interpreted to be interspecific, being too great to fall within the range of modern hominoid species. The multiple species solution rejects a sexual dimorphic explanation of variation because the degree of dimorphism in *H. habilis* falls outside the degree seen in modern hominoids. Moreover, multiple species proponents claim that *H. habilis* exhibits a pattern of sexual dimorphism that is markedly different from that which is observed in any analogues (e.g., females having larger brow ridges than males) (Lieberman et al. 1988; Kramer et al. 1995).

A comparison of the cranial capacity variability from *H. habilis sensu lato* to that of both modern humans and chimpanzees was used to assess which solution—single species or multiple species—is more substantiated by the available data on *H. habilis*.

Methods

Coefficient of Variation

The comparison of variability was conducted using the coefficient of variation (CV) of the cranial capacity from each hominid group—*H. habilis sensu lato*, *H. sapiens*, and *Pan troglodytes*. The CV was used primarily because it is a relative measure of variability. While the three hominid groups have vastly different mean cranial capacities, the calculation of CV puts the three hominid groups on a level playing field so that the internal variation within each group can be compared fairly to the variability in the other groups. All comparisons were based on raw CV scores.

Data Set

As noted above, three hominid groups were utilized in the CV comparison. Estimates of individual cranial capacities were collected for each set of referents. Modern *H. sapiens* were chosen because they are the descendents of, and morphologically similar to, early *Homo*. *P. troglodytes* were chosen because they are the taxon most closely related genetically to hominins (Caccone and Powell 1989). The *H. habilis* data set consisted of only those specimens with published cranial capacity estimates. The fossils included are: OH 7, 13, 16, 24 and KNM-ER 1470, 1590, 1805, 1813, and 3732. KNM-ER 1470, 1590, and 3732 are

those specimens with larger cranial capacities that are classified as *H. rudolfensis* by some paleoanthropologists (Lieberman et al. 1996).

The data set of modern humans consisted of six populations from various geographic areas. Three populations from within Africa were chosen — the Naqada from Egypt, the Teita from Kenya, and various crania from the Congo region — to determine if the variability within *H. habilis* was similar to variation among modern humans within a single region. Africa was specifically chosen as *H. habilis* has only been identified in that area. The three *H. sapiens* populations chosen are temporally and environmentally distinct to include a greater degree of variation between the modern samples. Samples from three other geographic regions— southern Burma, Tasmania, and England—were also included. These populations were chosen in order to include individuals from all major geographic regions of the Old World, assuming that a wide geographic range would encompass a high degree of variability. The sample size for each population was 30, with the exception of Tasmania where only 28 individuals were included. The sample sizes were restricted to 30 because of limitations of available published raw data. Thirty was the maximum number of individuals that would allow for the inclusion of a male to female ratio of (or as close to) one to one within each population. Because individuals were listed randomly by the original sources, the first 15 males and 15 females were included in the sample.

The data set for *P. troglodytes* consisted of 18 individuals (nine males, nine females) from the Frankfurt Collection of chimpanzee skeletons and 111 individuals (33 males and 78 females) from the Powell-Cotton Museum and Rothchild Museum Collections. Published data on *P. troglodytes* was limited and a subset of measurements was not selected. Instead, the smaller Frankfurt Collection population and the much larger Powell-Cotton and Rothchild Collections were included in their entirety.

For a list of individual cranial capacities and sources from which measurements were taken see Appendix A (*H. habilis*), Appendix B (*P. troglodytes*), and Appendix C (*H. sapiens*).

Calculations

The mean cranial capacities and standard deviations for the *H. habilis* sample, each *H. sapiens*

population, and the Frankfurt Collection of *P. troglodytes* were calculated using Excel (version 11.5.6). Raw individual measurements were not published for the Powell-Cotton and Rothchild Museum Collections of *P. troglodytes* so the mean and standard deviations published by Ashton and Spence (1958) were used instead.

The coefficient of variation was calculated for each data set using the formula;

$$CV = (\text{standard deviation} / \text{mean}) \times 100$$

The CV was also calculated for *H. habilis sensu stricto* by removing specimens KNM-ER 1470, 1590, and 3732. The CV for *H. rudolfensis* was calculated using the cranial capacities from only these three specimens.

Results

Table 1 provides a summary of all means, standard deviations, and CVs calculated. The CV of *H. habilis sensu lato* was 14.7. The range of variation in the CV of modern *H. sapiens* was 6.5-11.3. The range of variation in the CV of *P. troglodytes* was 5.4-10.5. The CV of *H. habilis sensu stricto* was 10.3 while the CV of *H. rudolfensis* was 5.5.

TABLE 1. Mean, Standard Deviation, and Coefficient of Variation for Sample Population				
Sample Population	Sample Size	Mean Cranial Capacity (cm ³)	Standard Deviation	Coefficient of Variation
<i>Homo habilis sensu lato</i>	9	666.4	98.2	14.7
<i>Homo habilis sensu stricto</i>	6	611.8	63.0	10.3
<i>Homo rudolfensis</i>	3	775.7	42.7	5.5
<i>Modern Homo sapiens</i>				
Naqada	30	1304.8	84.8	6.5
Teita	30	1273.8	116.2	9.1
Congo	30	1265.6	142.8	11.3
Burma	30	1347.5	116.7	8.7
Tasmania	28	1245.0	112.9	9.1
Moorfields	30	1419	144.5	10.2
<i>Pan troglodytes</i>				
Frankfurt Collection	18	367.7	19.8	5.4
Powell-Cotton & Rothchild Museums Collections*	111	390	41.1	10.5

*Mean and standard deviation values are from Ashton and Spence (1958). Raw data for individual measurements were not provided.

Discussion

H. habilis Variability in Comparison to Other Hominoid Species

The comparison of the CV of *H. habilis* to that of the CV range of both modern *H. sapiens* and *P. troglodytes* indicates that the cranial capacity of *H. habilis sensu lato* shows a higher degree of variation than that which occurs in the two reference samples: anatomically modern humans and chimpanzees. This comparison does not support a single species interpretation of the *H. habilis* hypodigm. While the highest variation in cranial capacity in the reference samples occurs in the Congolese humans, the CV of this population is 11.3 compared to the *H. habilis sensu lato* CV of 14.7. *H. habilis sensu lato* exhibits a higher CV than both the CV range of the three African human populations and of all six geographically widespread human populations. The CV of *H. habilis sensu lato* is even further outside of the CV range of chimpanzees than it is of modern *H. sapiens*. The CV of cranial capacity of *H. habilis sensu lato* is much greater than the range of variation observed in the two extant single species of which *H. habilis sensu lato* is closely related, thus supporting the view that the *H. habilis* hypodigm includes multiple species.

Only *H. sapiens* and *P. troglodytes* were included as reference samples because they are good indicators of an acceptable degree of intraspecific variation. However, single species proponents often argue that the CVs of gorillas and orangutans are better comparative values as both species show more intraspecific variation (Miller 1991). This study did not calculate CVs for these hominoid species but, instead, compared its values for *H. habilis* with published CVs for gorillas and orangutans. The highest published CV of cranial capacities for *Gorilla gorilla* is 13, while for *Pongo pygmaeus* it is 11 (Tobias 1971). Based on comparison with this study's calculated CV value of 14.7, the claim that the variability of *H. habilis* falls within the range of hominid species is rejected. While the variability in cranial capacity of *G. gorilla* approaches the degree seen in *H. habilis* it is still not large enough to conclude that *G. gorilla* is as variable as the specimens within the *H. habilis* hypodigm.

The CV values of *H. habilis sensu stricto* and *H. rudolfensis* provide further support for a multiple species solution to interpreting variability. When the large-brained specimens are removed from the sample, the CV of *H. habilis sensu stricto* falls well within the range of extant hominid species. While using only the samples from typical *H. rudolfensis*

specimens may be problematic as the sample size is reduced to three individuals, the CV also falls comfortably within range of modern humans and chimpanzees and thus is consistent with the pattern of that sample representing a single species, separate from *H. habilis sensu stricto*. Although age at death influences cranial capacity, in the above analysis the only specimens included were those from which cranial capacities from subadults were scaled to represent the capacity that would have been achieved in adulthood (Tobias 1991).

Sexual Dimorphism as a Possible Explanation of Variability

Beyond addressing whether or not the observed variability of *H. habilis sensu lato* is within the range of variation observed in extant hominid species, the above comparison of CV values also has implications for sexual dimorphism within this purported taxon. Differences in size between males and females cannot account for the high degree of cranial capacity variability within the *H. habilis* hypodigm. The reference samples used in this study's CV comparative analysis account for sexual dimorphism in that all samples include males and females and exhibit a large degree of intraspecific variation in cranial capacities (see Appendix C). For *H. habilis sensu lato* to be considered a single species it would have had to have been more sexually dimorphic than *G. gorilla* (Lieberman et al. 1988). While proponents of a single species solution could argue that the degree of sexual dimorphism in *H. habilis* cranial capacity indeed exceeds the amount of dimorphism in any extant hominoids, this argument must first be substantiated by providing evidence as to why dimorphism was more pronounced in *H. habilis* than in any other closely related species. Until this information is provided, paleoanthropologists must work with the available data and extant hominids are the most reasonable analogues for variability comparisons (Lieberman et al. 1996). CV values do not support the argument that *H. habilis* shows a similar degree of sexual dimorphism to extant gorillas or orangutans.

Beyond degree of variability, Rightmire (1996) notes that the pattern of variation in the *H. habilis* hypodigm is unlike that shared by any other extant references. If the larger specimens are interpreted as males, *H. habilis* exhibits a craniofacial morphology that is the reverse of what is observed

in extant dimorphic species. For example, the larger *H. habilis* (male) skulls exhibit less facial prognathism and smaller brow ridges than the smaller (female) skulls. Proponents of a single species model have yet to propose a satisfactory explanation of why *H. habilis* was more sexually dimorphic than any extant hominoids and why the patterning of sexual dimorphism was the opposite of what is observed today. It is more likely that the *H. habilis* hypodigm contains at least two species: a larger-brained *H. rudolfensis* and a smaller-brained *H. habilis*, each with its own pattern of sexual dimorphism.

Competitive Exclusion Principle

The above CV comparison indicates the presence of at least two very similar species co-existing around 1.8 MYA, which raises the question of the competitive exclusion principle. Some proponents of a single species solution argue that *H. habilis* cannot represent more than one species because two species competing for the same resources cannot co-exist—one species will out-compete the other (Hardin 1960). However this does not appear to be the case with *H. habilis* and *H. rudolfensis*. The competitive exclusion principle does not preclude the recognition of similar species co-existing if the species are occupying different ecological niches. Miller (2000), for example, notes that several sympatric hominin species co-existed, most notably those species identified in *Homo* and *Paranthropus*. It is reasonable to assume that because *H. habilis* and *H. rudolfensis* were morphologically distinct, they were also possibly behaviorally or ecologically distinct.

Sources of Error

The above comparative analysis of hominid CVs rejects sexual dimorphism as an explanation for the degree of variability observed in the *H. habilis* hypodigm and brings attention to the fact that the competitive exclusion principles does not exclude the concept of co-existence. However, it would be remiss to suggest that this analysis supports a multiple species solution without acknowledging the possible sources of error.

First, estimates of the cranial capacities of various *H. habilis* specimens are somewhat subjective as many specimens were highly

fragmented or incomplete and were reconstructed by different researchers, often utilizing distinct methods (cf. Wolpoff 1981; Tobias 1991; Holloway et al. 2004). As a result, the CV values may differ from other published results depending on which cranial capacity measurements are utilized. Moreover, the cranial capacity measurements of the reference samples were taken by different researchers and thus the accuracy of the above CV calculations are dependent upon the reliability of those raw measurements.

The CV value comparison between *H. habilis sensu stricto* and *H. rudolfensis* is somewhat biased as *H. habilis sensu lato* was divided based on a standard literature divisions (e.g. Lieberman et al. 1996) and was not conducted blindly.

The validity of the *H. habilis* hypodigm used in this analysis may also be questioned. For example, ER 3732 is classified above as *H. rudolfensis* based on its larger cranial capacity but the specimen also exhibits substantial supraorbital tori—a trait presumed to be characteristic of *H. habilis sensu stricto* (Rightmire 1996). Thus the assignment of ER 3732 to *H. rudolfensis* is complicated.

It is also important to note that only three individuals were utilized in the *H. rudolfensis* sample. With a small number of specimens, the statistical relevance of the sample is questionable and an argument for a multiple species solution using only this sample cannot be made confidently. However, the inclusion of this group in the analysis was used to demonstrate that the CV of the sample falls within range of modern humans and chimpanzees and thus is consistent with the general pattern of the sample representing a single species.

Lastly, the conclusions made from the comparison of CV values rely upon the assumption that the reference samples capture the true degree of variation in extant humans and chimpanzees. However, the true range of variation present in a species cannot be known with absolute certainty without including every individual of that species—an impossible task.

While these source of error are included to acknowledge possible explanations of the variance between this study's calculated CVs and other published values, they do no way imply that these possible errors indicate that the multiple species

solution is not the best-supported explanation of the degree of variability in the *H. habilis* hypodigm. The researchers responsible for providing the cranial capacities of *H. habilis* rigorously tested their estimations and provided strong arguments as to why their measurements are accurate (see Tobias 1991; Conroy et al. 1998; Holloway et al. 2004). Six human populations from widely distributed geographic areas were also utilized to ensure the inclusion of a wide range of cranial capacity variability. Given the current data available, I am confident that the CVs presented in Table 1 are accurate representations of the degree of variability in *H. habilis*, *H. sapiens*, and *P. Troglodytes*.

Conclusion

While the *H. habilis* hypodigm exhibits a considerable degree of variation, a comparison of the coefficient of variation of the cranial capacities of *H. habilis*, modern *H. sapiens*, and *P. troglodytes* indicates that the best solution for interpreting such variability is the recognition of multiple species of early Homo. The CV scores of the human and chimpanzee populations represent the acceptable range of variation within a single species. Modern human populations range in their CVs from 6.5-11.3 while the CV of *P. troglodytes* ranges from 5.4-10.5 and thus "normal" variation is quantified as a CV value that falls within the range of 5.4 to 11.3. *H. habilis sensu lato* has a cranial capacity CV of 14.7, clearly falling beyond the range of the normal degree of variation within a single species. Sexual dimorphism, having been accounted for in the reference samples, cannot adequately explain the morphological differences in the skulls of *H. habilis* specimens. Instead, paleoanthropologists must reconsider taking a single species solution approach and explore further the possibility of a multiple species interpretation of the *H. habilis* hypodigm. The acceptance that *H. habilis sensu lato* represents multiple species will have specific implications for early Homo research, probably the most important of such being the requirement of a reorganization of those existing phylogenies that only recognize a single species of *H. habilis*. While proponents of the multiple species solution may already separate *H. habilis* from *H. rudolfensis* (e.g., Klein 2009), I suggest that paleoanthropologists must further focus on determining the evolutionary relationships between the two early Homo species both to each

other and to the later *H. ergaster*, and ultimately to anatomically modern *H. sapiens*.

I do not intend to suggest that my singular comparison of coefficients of variation has provided a definitive end to the debate surrounding the *H. habilis* hypodigm. Indeed, while I have argued that my calculations are accurate representations of the degree of variability of cranial capacity within three hominid groups, I recognize that not all paleoanthropologists will agree with my results. CV values currently in the literature not only differ from my own values but also differ from each other (see Miller 1991). I intended for this paper to illuminate the need for paleoanthropology in general to develop a standardized measure of the acceptable degree of variation allowed within a single species. This is no doubt a daunting task, but focusing on statistical methods will prove most fruitful as they forward a more objective methodology. I further suggest that the standardized measure of variability must move beyond cranial capacity to include multiple craniodental measurements. While the *H. habilis* hypodigm shows quite a distinct divide between small and large cranial capacities (see Appendix A), paleoanthropologists in the future may need to interpret more subtle differences in morphology. In the end, the fragmentary nature of the fossil record means that variability will always be an issue in paleoanthropological research. However, paleoanthropologists cannot wait for a more complete picture to emerge — they must make interpretations that can be revised later in light of new evidence. I have taken this step by utilizing available information to evaluate *H. habilis sensu lato* and to demonstrate that the *H. habilis* hypodigm may indeed represent multiple species.

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APPENDIX A: Cranial Capacity Measurements for *Homo habilis* Sample

<i>Homo habilis</i>	Cranial Capacity (cm ³)	Source
OH 7	674	Tobias (1991)
OH 13	673	Tobias (1991)
OH 16	638	Tobias (1991)
OH 24	594	Tobias (1991)
KNM- ER 1470*	752	Holloway et al. (2004)
KNM-ER 1590*	825	Holloway et al. (2004)
KNM-ER 1805	582	Conroy et al. (1998)
KNM-ER 1813	510	Conroy et al. (1998)
KNM-ER 3732*	750	Holloway et al. (2004)
Mean	666.4	
Standard Deviation	98.2	

*Classified as *Homo rudolfensis* by Lieberman et al. (1996)

APPENDIX B: Cranial Capacity Measurements for Two *Pan troglodytes* Samples

<i>Pan troglodytes</i>	Cranial Capacity (cm ³)	Source
Frankfurt Collection		Protsch von Zieten et al. (1987)
Specimen 1	364	
Specimen 2	378	
Specimen 3	368	
Specimen 4	376	
Specimen 5	375	
Specimen 6	374	
Specimen 7	376	
Specimen 8	404	
Specimen 9	345	
Specimen 10	361	
Specimen 11	386	
Specimen 12	381	
Specimen 13	355	
Specimen 14	393	
Specimen 15	360	
Specimen 16	344	
Specimen 17	360	
Specimen 18	318	
Mean	367.7	
Standard Deviation	19.8	

<i>Pan troglodytes</i>	Cranial Capacity (cm ³)	Source
Powell-Cotton Museum and Rothchild Museum Collections*		Ashton and Spence (1958)
Sample size	111	
Mean	390	
Standard Deviation	41.1	

*Mean and standard deviation values are from Ashton and Spence (1958).

Raw data for individual measurements were not provided.

APPENDIX C: Cranial Capacity Measurements for Six Modern *Homo sapiens* Samples

Modern <i>Homo sapiens</i>	Sex	Cranial Capacity (cm ³)	Source
Africa - Congo			Benington & Pearson (1912)
Specimen 1	M	1208	
Specimen 2	M	1430	
Specimen 3	M	1195	
Specimen 4	M	1175	
Specimen 5	M	1388	
Specimen 6	M	1235	
Specimen 7	M	1180	
Specimen 8	M	1438	
Specimen 9	M	1615	
Specimen 10	M	1400	
Specimen 11	M	1315	
Specimen 12	M	1458	
Specimen 13	M	1320	
Specimen 14	M	1088	
Specimen 15	M	1355	
Specimen 16	F	1327	
Specimen 17	F	1266	
Specimen 18	F	1445	
Specimen 19	F	1286	
Specimen 20	F	1123	
Specimen 21	F	1182	
Specimen 22	F	1150	
Specimen 23	F	1068	
Specimen 24	F	1393	
Specimen 25	F	1130	
Specimen 26	F	1205	
Specimen 27	F	1135	
Specimen 28	F	948	
Specimen 29	F	1267	
Specimen 30	F	1242	
Mean		1265.6	
Standard Deviation		142.8	

Modern <i>Homo sapiens</i>	Sex	Cranial Capacity (cm ³)	Source
Africa - Teita			Kitson (1931)
Specimen 1	M	1441	
Specimen 2	M	1429	
Specimen 3	M	1187	
Specimen 4	M	1418	
Specimen 5	M	1390	
Specimen 6	M	1492	
Specimen 7	M	1149	
Specimen 8	M	1138	
Specimen 9	M	1229	
Specimen 10	M	1338	
Specimen 11	M	1291	
Specimen 12	M	1321	
Specimen 13	M	1176	
Specimen 14	M	1342	
Specimen 15	M	1389	
Specimen 16	F	1380	
Specimen 17	F	1191	
Specimen 18	F	1347	
Specimen 19	F	1204	
Specimen 20	F	1392	
Specimen 21	F	1229	
Specimen 22	F	1095	
Specimen 23	F	1199	
Specimen 24	F	1353	
Specimen 25	F	1175	
Specimen 26	F	1109	
Specimen 27	F	1081	
Specimen 28	F	1194	
Specimen 29	F	1342	
Specimen 30	F	1194	
Mean		1273.8	
Standard Deviation		116.2	

Modern <i>Homo sapiens</i>	Sex	Cranial Capacity (cm ³)	Source
Africa - Naqada			Fawcett & Lee (1902)
Specimen 1	M	1275	
Specimen 2	F	1345	
Specimen 3	F	1379	
Specimen 4	M	1310	
Specimen 5	M	1440	
Specimen 6	M	1283	
Specimen 7	F	1303	
Specimen 8	M	1243	
Specimen 9	F	1325	
Specimen 10	F	1302	
Specimen 11	M	1420	
Specimen 12	M	1397	
Specimen 13	M	1545	
Specimen 14	F	1272	
Specimen 15	F	1220	
Specimen 16	F	1205	
Specimen 17	F	1190	
Specimen 18	M	1288	
Specimen 19	F	1315	
Specimen 20	M	1265	
Specimen 21	F	1365	
Specimen 22	F	1225	
Specimen 23	M	1358	
Specimen 24	F	1275	
Specimen 25	M	1260	
Specimen 26	F	1280	
Specimen 27	M	1230	
Specimen 28	F	1185	
Specimen 29	F	1440	
Specimen 30	F	1205	
Mean		1304.8	
Standard Deviation		84.8	

APPENDIX C: continued

Modern <i>Homo sapiens</i>	Sex	Cranial Capacity (cm ³)	Source
Australia - Tasmania			Wunderly (1939)
Specimen 1	M	1270	
Specimen 2	M	1250	
Specimen 3	M	1378	
Specimen 4	M	1150	
Specimen 5	M	1366	
Specimen 6	M	1184	
Specimen 7	M	1336	
Specimen 8	M	1362	
Specimen 9	M	1122	
Specimen 10	M	1106	
Specimen 11	M	1140	
Specimen 12	M	1320	
Specimen 13	M	1316	
Specimen 14	M	1160	
Specimen 15	M	1498	
Specimen 16	F	1098	
Specimen 17	F	1080	
Specimen 18	F	1150	
Specimen 19	F	1128	
Specimen 20	F	1296	
Specimen 21	F	1130	
Specimen 22	F	1428	
Specimen 23	F	1275	
Specimen 24	F	1252	
Specimen 25	F	1322	
Specimen 26	F	1220	
Specimen 27	F	1362	
Specimen 28	F	1160	
Mean		1245.0	
Standard Deviation		112.9	

Modern <i>Homo sapiens</i>	Sex	Cranial Capacity (cm ³)	Source
Europe - Moorfields			MacDonell (1906)
Specimen 1	M	1605	
Specimen 2	M	1427	
Specimen 3	M	1247	
Specimen 4	F	1425	
Specimen 5	M	1589	
Specimen 6	F	1399	
Specimen 7	M	1476	
Specimen 8	M	1450	
Specimen 9	M	1425	
Specimen 10	M	1486	
Specimen 11	M	1670	
Specimen 12	F	1460	
Specimen 13	M	1207	
Specimen 14	F	1476	
Specimen 15	F	1202	
Specimen 16	F	1121	
Specimen 17	F	1541	
Specimen 18	M	1394	
Specimen 19	F	1405	
Specimen 20	F	1308	
Specimen 21	F	1531	
Specimen 22	F	1440	
Specimen 23	M	1470	
Specimen 24	F	1425	
Specimen 25	F	1384	
Specimen 26	F	1227	
Specimen 27	M	1643	
Specimen 28	F	1313	
Specimen 29	M	1648	
Specimen 30	F	1176	
Mean		1419	
Standard Deviation		144.5	

Modern <i>Homo sapiens</i>	Sex	Cranial Capacity (cm ³)	Source
Asia - Burma			Tildesley (1921)
Specimen 1	M	1496	
Specimen 2	M	1264	
Specimen 3	M	1614	
Specimen 4	M	1382	
Specimen 5	M	1416	
Specimen 6	M	1359	
Specimen 7	M	1459	
Specimen 8	M	1430	
Specimen 9	M	1413	
Specimen 10	M	1421	
Specimen 11	M	1380	
Specimen 12	M	1330	
Specimen 13	M	1474	
Specimen 14	M	1338	
Specimen 15	M	1389	
Specimen 16	F	1277	
Specimen 17	F	1248	
Specimen 18	F	1086	
Specimen 19	F	1091	
Specimen 20	F	1216	
Specimen 21	F	1443	
Specimen 22	F	1418	
Specimen 23	F	1343	
Specimen 24	F	1412	
Specimen 25	F	1323	
Specimen 26	F	1254	
Specimen 27	F	1336	
Specimen 28	F	1405	
Specimen 29	F	1170	
Specimen 30	F	1239	
Mean		1347.5	
Standard Deviation		116.7	

Community in *World of Warcraft*: The Fulfilment of Social Needs

Caroline Whippey

Introduction

Online communities are becoming more prevalent as Internet technology continues to mature. One type of these communities is found in the genre of Massively Multiplayer Online Role Playing Games (MMORPGs). While there is a growing literature on the subject of online gaming communities, anthropology has not yet made an extensive contribution. In this study, I argue that *World of Warcraft's* (WoW) social community helps to fulfill various social and emotional needs of its

players. WoW has been selected for this study because it is one of the most popular games of its kind, currently having a player base of over 11.5 million people (Blizzard 2008). This study provides valuable information about the social interaction in online gaming as well as emphasizes the need for anthropologists to study online gaming communities.

In order to discuss the inner workings of the WoW community, it is essential to examine the notion of "gaming culture". Subsequently, an