# On Setting an Initial GC Handicap for an Experienced AC Player

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## *Rationale*

We wish to investigate if there is a reasonable relationship between AC and GC handicaps that can be used to assist in the initial setting of a GC handicap for a player who has AC experience. This is due to an indication that such players are starting with a GC handicap somewhat high relative to where they should be. There is no definition of what constitutes an "experienced" AC player.

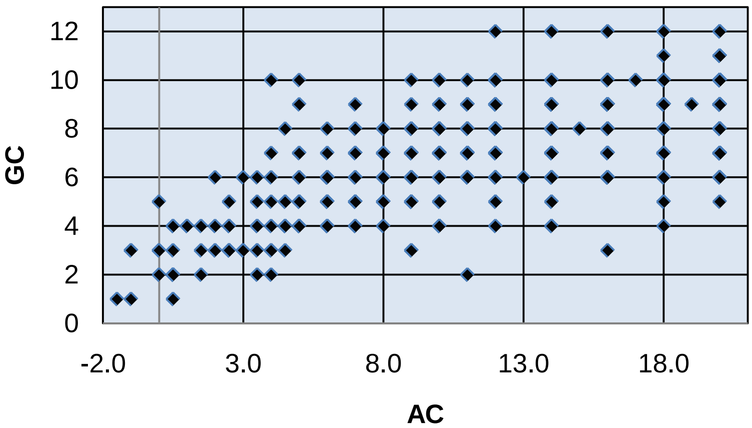
## *Data*

Electronic data has been obtained from NSW (593 data points), SA (163 data points) & Tasmania (151 data points). This gives a total of 907 players with AC and GC handicaps from a total of 3 states. In the data AC handicaps range from -1.5 to 24; GC handicaps from 1 to 12. As we are looking at "experienced" AC players we will limit the maximum AC handicap used to 20. This leaves 777 data points.

## *Analysis*

Using the data we may plot the relationship between AC and GC handicaps (Figure 1). This figure shows no strong correlation between the two handicaps for this data sample. There is too much variation in GC handicaps for a given an AC handicap. For example, we see GC handicaps between 3 and 12 for an AC handicap of 16. This does seem to imply quite a large range of GC skills at that AC handicap. It is probable that the data quality is somewhat variable.

**Figure 1. Relationship between AC and GC handicaps (using AC handicaps ≤ 20)**



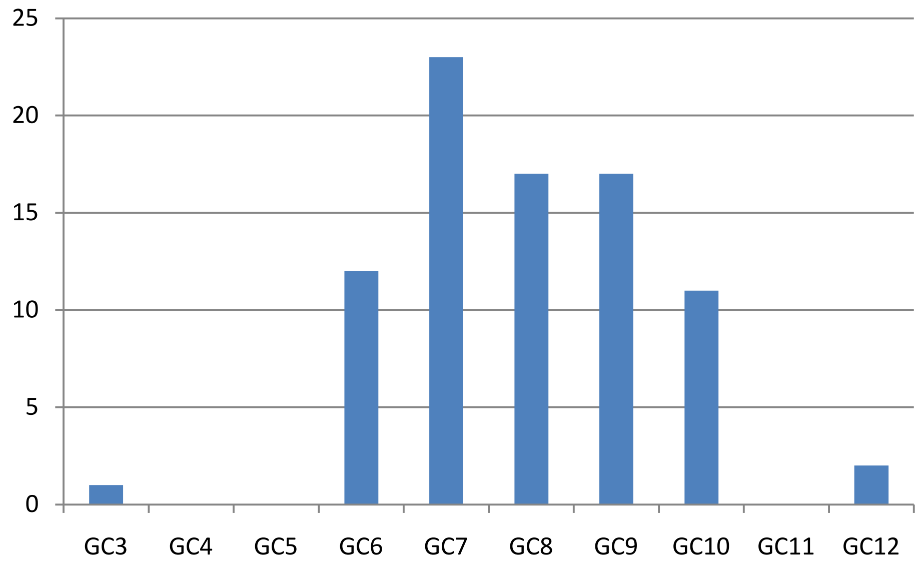

A somewhat better method of analysing the data to extract a usable relationship between AC and GC handicaps is to look at the number of players represented by each point in figure 1. That is, how many players have each pair of handicaps? This is tabulated in Table 1.

**Table 1. Numbers of players with a given AC and GC Handicap in the sample data. The largest number is highlighted for each AC Handicap.**

| | GC Handicap | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AC Handicap** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
| **-1.5** | **1** | | | | | | | | | | | |
| **-1** | 1 | | **2** | | | | | | | | | |
| **0** | | 1 | **2** | | 1 | | | | | | | |
| **0.5** | 1 | **4** | 1 | 2 | | | | | | | | |
| **1** | | | | **2** | | | | | | | | |
| **1.5** | | **1** | **1** | **1** | | | | | | | | |
| **2** | | | **2** | 1 | | 1 | | | | | | |
| **2.5** | | | **4** | 2 | 1 | | | | | | | |
| **3** | | | **3** | | | 1 | | | | | | |
| **3.5** | | 1 | **2** | **2** | 1 | 1 | | | | | | |
| **4** | | 1 | **2** | 1 | 1 | 1 | 1 | | | 1 | | |
| **4.5** | | | 1 | **3** | 2 | | | 1 | | | | |
| **5** | | | | **4** | 3 | 3 | 3 | | 1 | 1 | | |
| **6** | | | | 3 | 5 | **13** | 2 | 1 | | | | |
| **7** | | | | 2 | **5** | 4 | **5** | 2 | 1 | | | |
| **8** | | | | 1 | 5 | 6 | **8** | 3 | | | | |
| **9** | | | 2 | | 6 | **10** | **10** | 6 | 1 | 1 | | |
| **10** | | | | 3 | 3 | 8 | 15 | **16** | 3 | 2 | | |
| **11** | | 1 | | | | 12 | **14** | 11 | 5 | 1 | | |
| **12** | | | | 1 | 2 | 14 | 12 | **20** | 10 | 8 | | 1 |
| **14** | | | | 2 | 2 | 12 | **17** | 14 | 12 | 3 | | 2 |
| **16** | | | 1 | | | 12 | **23** | 17 | 17 | 11 | | 2 |
| **18** | | | | 1 | 2 | 7 | 16 | 17 | **22** | 18 | 1 | 3 |
| **20** | | | | | 1 | 14 | 28 | 25 | 34 | **92** | 5 | 3 |

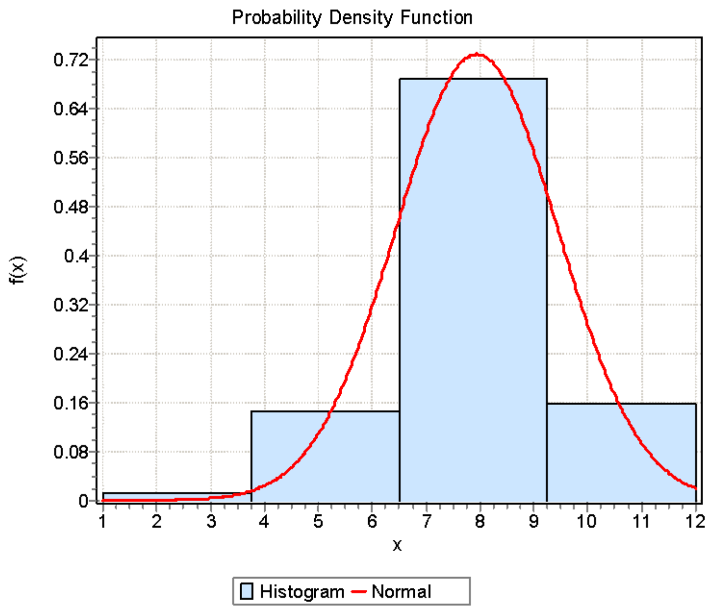
Taking as an example those players with an AC handicap of 16, we may plot a histogram of the numbers of those with different GC Handicaps (Figure 2)

**Figure 2. Number of Players (AC Handicap=16)**



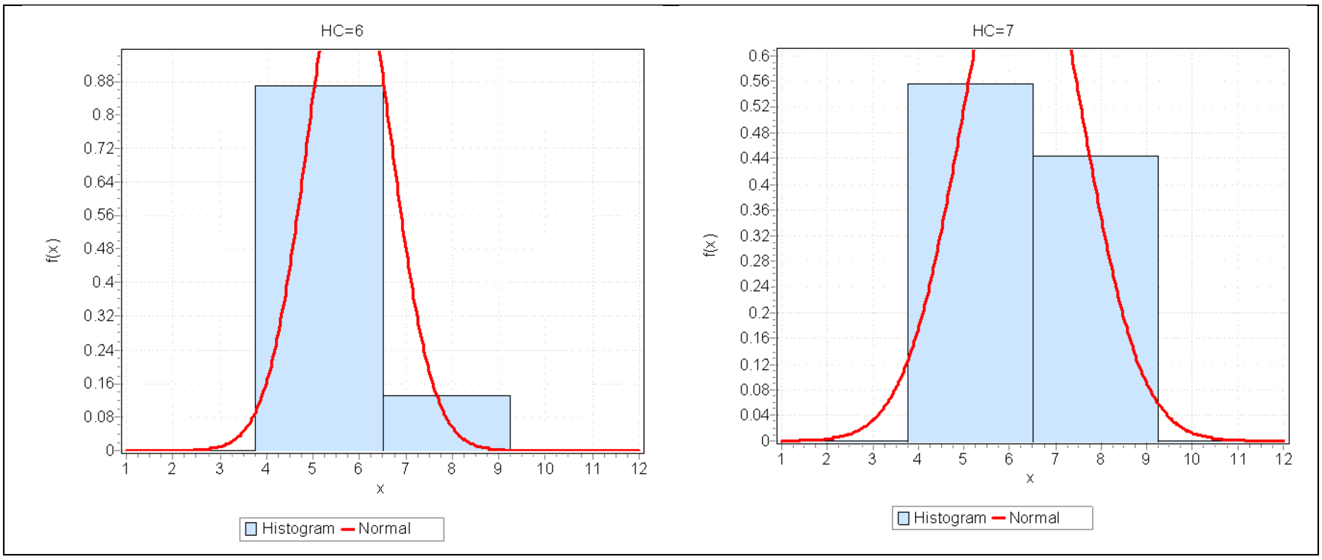

Such a distribution as shown in Figure 2 may be fit by a normal distribution. Doing so leads to a mean GC handicap value of ($\mu$) of 7.94 with a standard deviation ($\sigma$) of 1.51 (Figure 3).

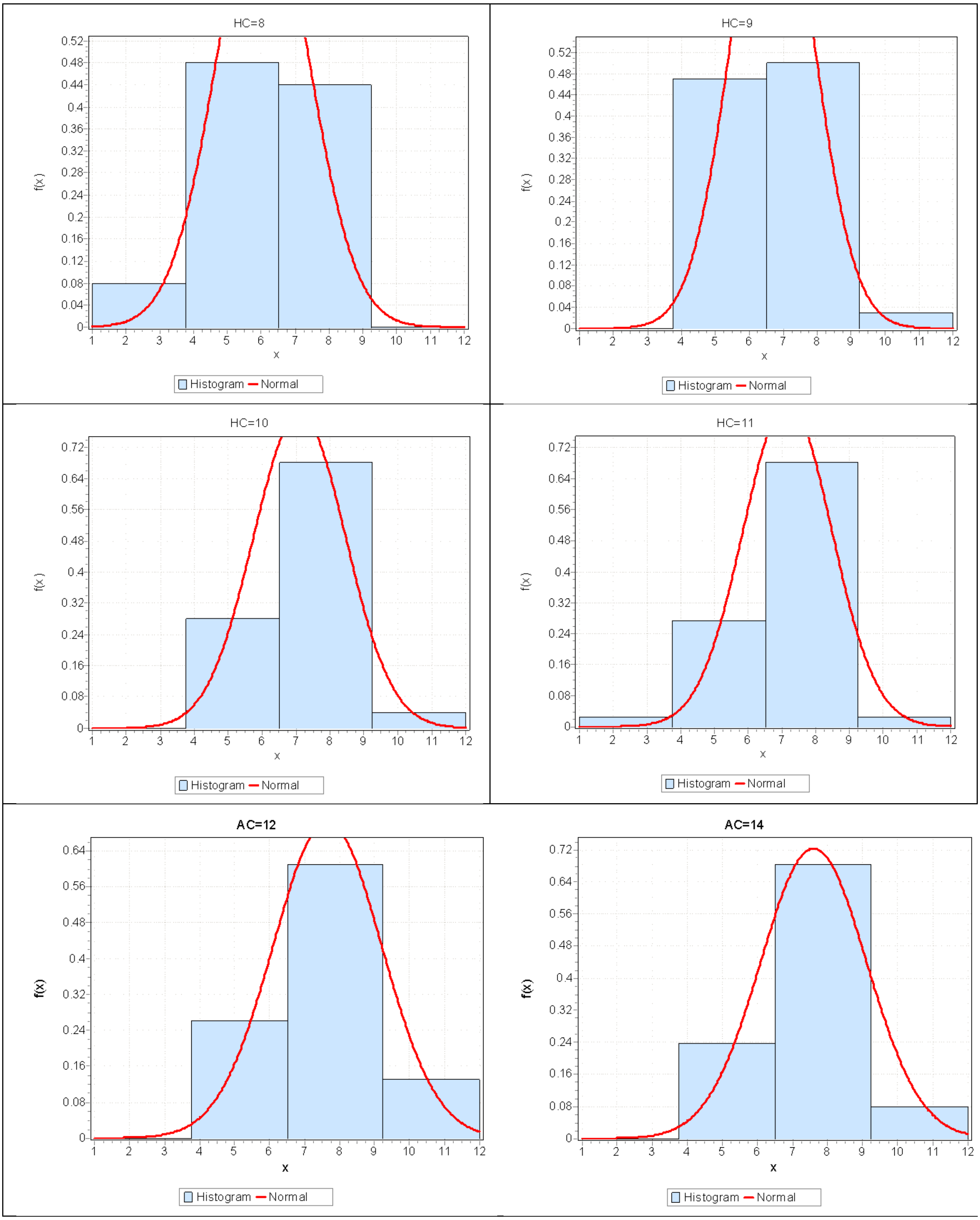
**Figure 3. Normal Distribution Fit to GC Handicaps for AC Handicap=16**




This appears to give a reasonable method with which to determine a GC handicap given an AC one. To investigate this further the above fitting procedure is used for all AC handicaps from -1.5 to 20 where there exists at least 20 data points (from Table 1). Resultant histograms and normal distribution fits are shown in Figure 4, with the derived mean and standard deviation values given in Table 2.

**Figure 4. Histograms and Gaussian fit to Measured GC Handicaps for AC Handicaps from 6 - 20 (AC Handicap=16 is shown in Figure 3).**




HC=8
HC=9
HC=10
HC=11
AC=12
AC=14
f(x)
x
Histogram
Normal

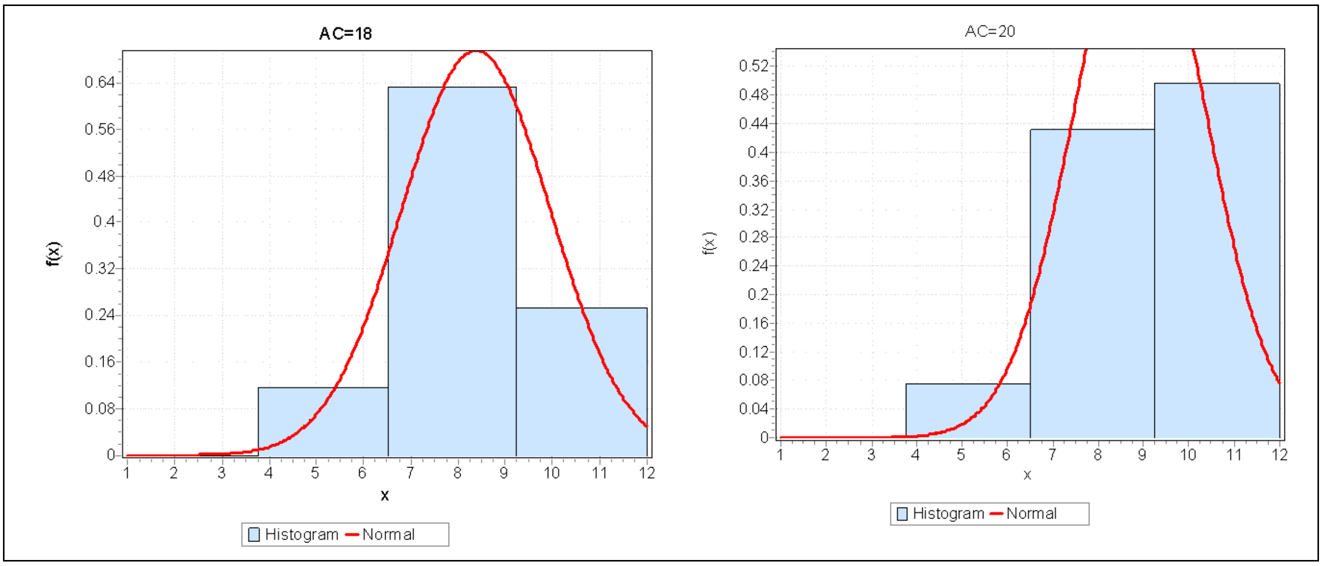


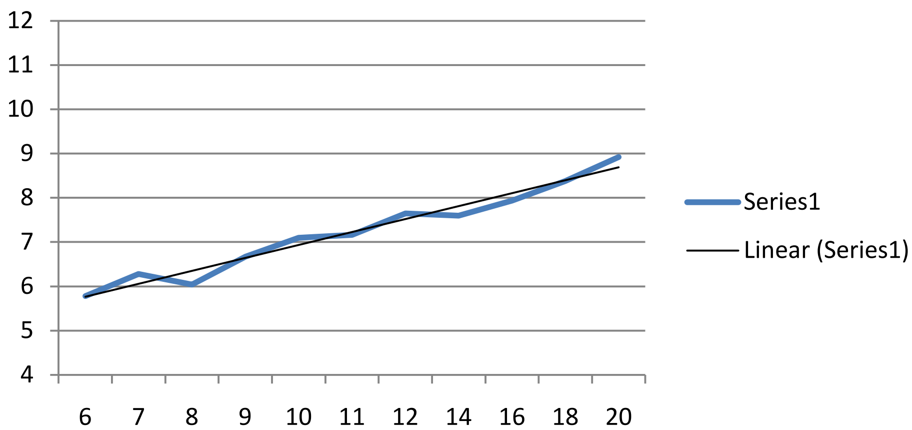

**Table 2. Gaussian fit for each AC Handicap. The Mean (μ) is the derived GC Handicap.**

| AC Handicap | Mean (μ) | Std Dev (σ) |
|---|---|---|
| 6 | 5.78 | 0.88 |
| 7 | 6.28 | 1.28 |
| 8 | 6.04 | 1.37 |
| 9 | 6.67 | 1.20 |
| 10 | 7.10 | 1.36 |
| 11 | 7.16 | 1.31 |
| 12 | 7.65 | 1.56 |
| 14 | 7.60 | 1.52 |
| 16 | 7.94 | 1.51 |
| 18 | 8.38 | 1.58 |
| 20 | 8.92 | 1.44 |

Using Table 2 we may now plot the relationship between AC Handicap and the Mean Gaussian value (Figure 5). This is effectively a linear relationship. Figure 5 also shows the least-squares fit which is

$$GC = 4.73 + 0.21 * AC$$

**Figure 5. Derived linear relationship between AC and GC Handicaps.**




It may be the case that a simple Gaussian fit to the highest handicap data is not the best method. The shape of the histograms for AC handicaps 18 and 20 indicates that for a pure Gaussian distribution we are missing data at higher GC handicaps. That is, there should be some data points with GC handicaps > 12. If this is the case then the mean values in Table 2 above are slightly low for those AC handicaps of 18 and 20. Adding just a small number of fake higher handicap data pushes the derived GC Handicaps 1 higher.

## *Comparison with South Australia Tabulation*

South Australia has compiled a tabulated set of AC and GC handicaps. Taking their values and putting into the format in this document leads to the values in Table 3. There is some ambiguity in their table as some handicaps are listed twice. This is reflected by two values in Table 3. For comparison the values derived in this paper are also listed in Table 3.

The fact that there is agreement to within 1 extra turn in all compared handicaps is reassuring.

**Table 3. Comparison of South Australian AC/GC Tabulation with this paper. Values in bracket are those derived assuming some high handicap information is missing from the data.**

| AC Handicap | South Australia | This Paper |
|---|---|---|
| | GC Handicap | |
| 6 | 6 | 6 |
| 7 | 7 | 6 |
| 8 | 7 | 6 |
| 9 | 7 | 7 |
| 10 | 8 | 7 |
| 11 | 8 | 7 |
| 12 | 8 | 8 |
| 14 | 8 or 9 | 8 |
| 16 | 9 | 8 |
| 18 | 9 | 8 (9) |
| 20 | 10 | 9 (10) |

## *Other Handicaps*

The questions may be asked: What about players with lower AC handicaps? What should be their starting GC Handicap?

It is tempting to extend the range of the linear fit to lower AC handicaps. It is unfortunate that we do not have sufficient data to perform a reliable Gaussian fit to the few data points for lower AC handicaps.  Looking at Table 1 it is clear that the general trend does continue. If we were to extend the linear relationship presented in Figure 5 to an AC Handicap of 0 we have the results in Table 4. Table 4 also contains the South Australian tabulated values at corresponding handicaps. For simplicity only integral AC Handicap values are listed.

**Table 4. Comparison of Victorian AC/GC Tabulation with this paper (extrapolated from Figure 5).**

| AC Handicap | South Australia | This Paper |
|---|---|---|
| | GC Handicap | |
| 0 | 3 | 5 |
| 1 | 4 | 5 |
| 2 | 4 | 5 |
| 3 | 5 | 5 |
| 4 | 5 | 6 |
| 5 | 6 | 6 |

The agreement is to within 1 extra turn with the exception of the case with an AC Handicap of zero. There is, however, no reason to believe that the relationship should be linear across all AC Handicaps. Indeed, it is known that AC Handicaps are not linearly distributed. From Figure 1 there is a good indication that for lower AC handicaps (below around 5) that the relationship between AC and GC handicaps no longer follows the simple linear equation derived in this paper. Extreme care should be exercised at any time extrapolation is used.

It would be expected that players with lower AC Handicaps will more than likely be found on the AC World rankings list. The WCF Golf Croquet Rules (2007) give starting GC Handicaps for such players.

## *Conclusions*

A reasonably linear relationship has been found to exist between AC and GC Handicaps in the range of AC Handicaps for which sufficient data has been supplied. The quality of this relationship, when compared with an empirically tabulated list from South Australia, gives confidence that a method will be able to be used to assign initial GC Handicaps to experienced AC players that should be within ±1 extra turn. Table 6 lists those values.

**Table 6. Allocation of Initial GC Handicaps for Experienced AC Players**

| AC Handicap | Initial GC Handicap |
|---|---|
| 6-8 | 6 |
| 9-11 | 7 |
| 12-16 | 8 |
| 18 | 9 |
| 20 | 10 |

This relationship should not be extended to lower handicaps at this time due to the lack of data. If sufficient additional data is available in future then this should be revisited.

## *Recommendations*

**Recommendation 1:** Table 6 above should be used for the initial allocation of a GC Handicap to a player experienced in AC subject to Recommendation 2 below.

**Recommendation 2:** Players experienced in AC but new to GC continue to carry out the objective test as per the Appendix to the WCF Golf Croquet Rules (2007). If such indicates a lower starting GC Handicap than from Table 6 the lower value should be used.

We need a suitable definition of what constitutes an "experienced" AC player. I would propose that be a player with at least 6 months of AC play.