Neuropsychological and Psychiatric Functioning in Sheep Farmers Exposed to Organophosphate Pesticides

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ADDITIONAL ANALYSES

Exposed Cohort versus Normative Comparison Standards: Re-analysis of the data using an alternative comparison group.

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A potential weakness of this study design which could limit the conclusions that can be drawn from the above analyses was the recruitment of rural police workers as an unexposed control group. Although matched to the farmers as far as possible in terms of characteristics which may affect cognitive function (i.e. age, gender, education level, premorbid IQ), police workers differ from farmers in terms of the exact nature of the work they undertake, lifestyle and life experiences. Differences in performance on neuropsychological testing between exposed farmers and unexposed rural police workers could be due to an unidentified confounder that was not controlled for in this study and may not reflect exposure history.

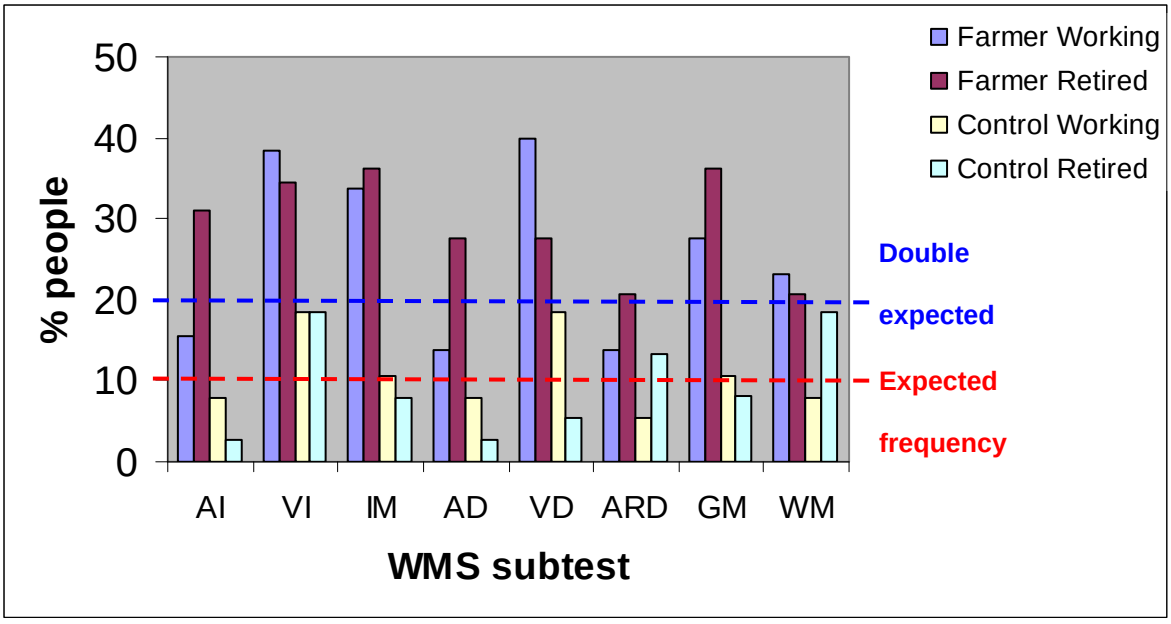
Therefore, the above analyses were repeated using normative comparison standards. The neuropsychological test battery consisted of well known, reliable and clinically sensitive measures for which population test norms are available. For example, the Wechsler Adult Intelligence scale and the Wechsler Memory Scale (Wechsler scales) have been developed over many years and the current editions are the result of extensive empirical studies in the US and UK involving a standardisation sample of over 2000 adults aged 16-90 years. The sample was divided into 13 age groups and stratified on key demographic variables including age, sex, years in education, race/ethnicity, geographic region. Extensive testing of reliability and validity were undertaken, including validation studies on clinical populations (learning disability, cortical and subcortical dementias, traumatic brain injury, multiple sclerosis, epilepsy, alcohol abuse, schizophrenia). The Wechsler scales provide contemporary normative information and interpretive tables allowing an individual's performance on these scales to be compared to national norms. Test norms were also available for all other measures included in our battery.

To determine whether organophosphates have a negative effect on cognitive function, the pattern of performance of both exposed farmers and unexposed rural police workers was compared to what one would expect to see in the normal population.

Wechsler Memory Scale – III (WMS-III)

The Wechsler Memory Scale – III (WMS-III) was used to assess working, visual and auditory memory. Discrepancies between Intelligence (IQ) and memory are sometimes used to evaluate memory functioning. IQ score can be used as an index of probable, premorbid level of memory ability. Discrepancy scores between the IQ estimated memory performance and actual memory performance were calculated and indicate whether the examinees ability to learn and recall information is commensurate with what would be expected given their intellectual functioning. Farmers were more likely than rural police workers to have statistically significant differences between their IQ and memory scores and Figure 1 shows the percentage of people performing on the WMS-III sub-tests at an impairment level only expected in 10% of the standardization sample. Farmers are more than twice as likely to suffer from impairments on visual, working and general memory measures than the standardization sample and police workers. In addition, retired farmers are more likely to be impaired on auditory memory.

Figure 1: Percentage of people performing on the WMS-III sub-tests at an impairment level only expected in 10% of the population



A series of binomial tests with .1 set as the proportion of expected impairment revealed that none of the police workers significantly deviated from the expected 10% frequency. In contrast, binomial tests revealed that significantly more working farmers were impaired than one would have expected on measures of visual, immediate and general memory (VI, VD,IM, GM; $p<.001$ for all) and working memory (WM; $p<.01$). Retired farmers were shown to be significantly impaired on all measures (WM and GM $p<.01$, all other measures $p<.001$).

Wechsler Adult Intelligence Scale-III (WAIS-III)

The WAIS III was administered to assess participants' current intellectual functioning. The test is comprised of 14 subtests which can also be used to measure a range of specific cognitive functions such as working memory, response speed, verbal ability, verbal and visual reasoning and visuo-spatial ability. Figure 2 depicts the pattern of performance of study participants on the different WAIS-III subtests and Figure 3 shows the percentage of people in each group with significant impairment on WAIS sub-tests according to published test norms.

Figure 2: Performance profiles on WAIS-III sub-tests (error bars represent ±2 S.E.)

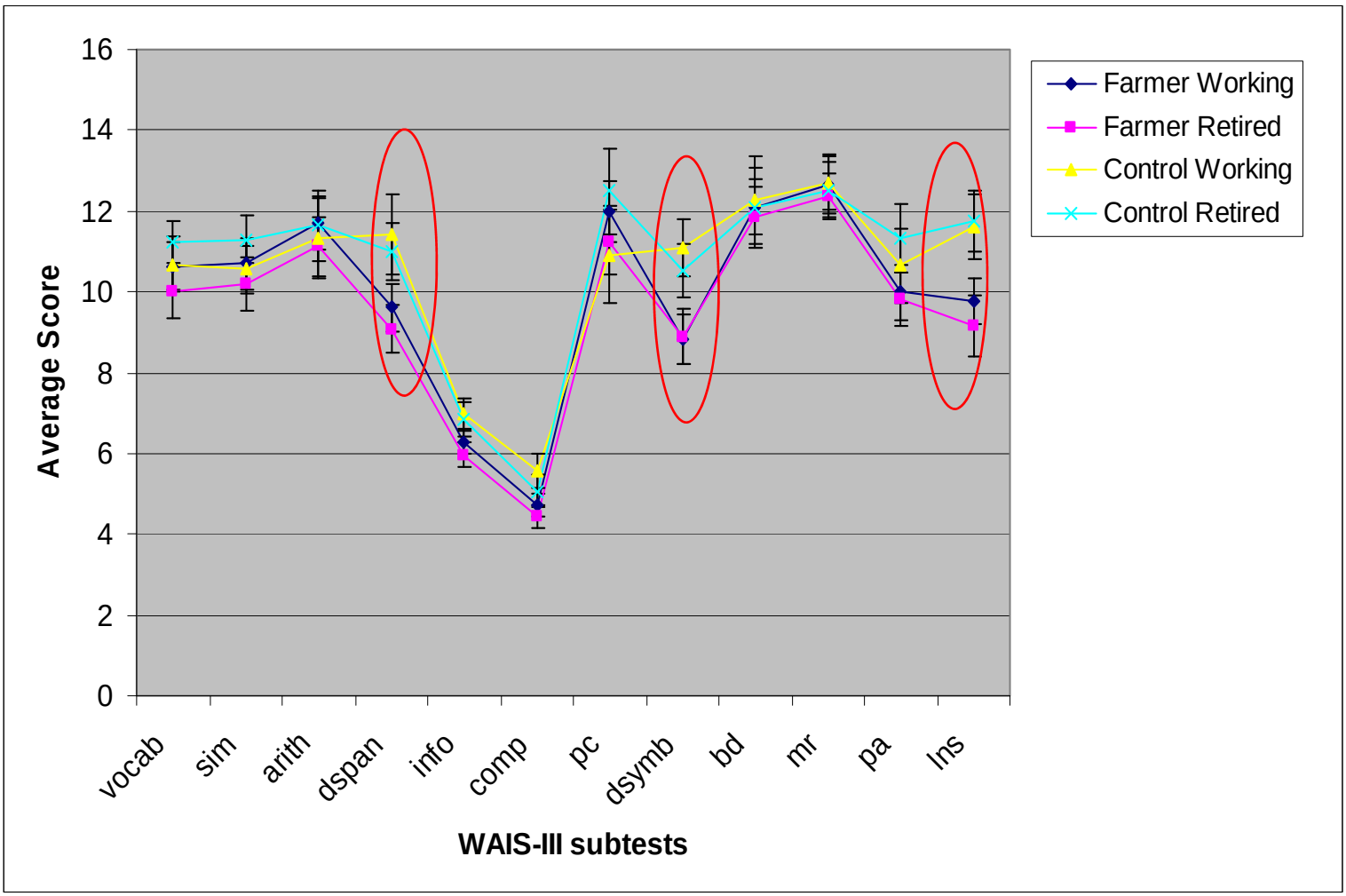
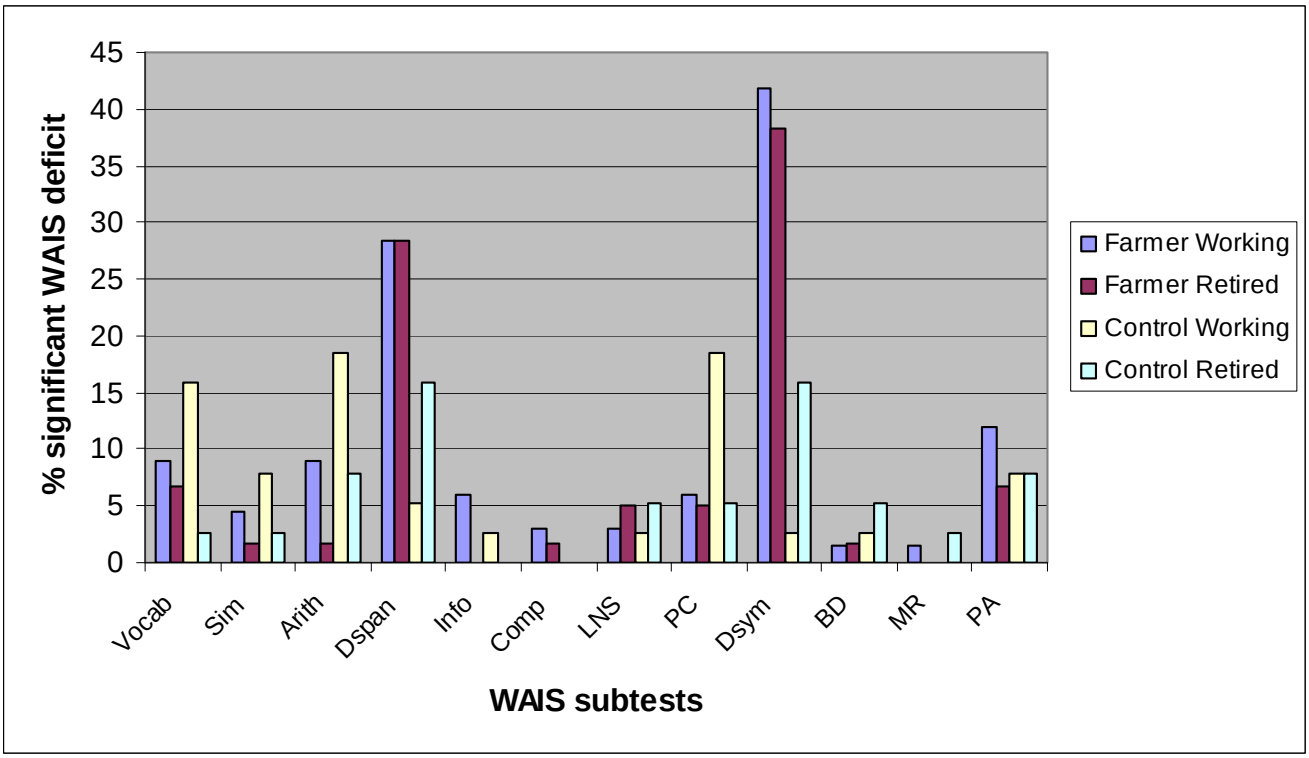


Figure 3: Percentage of people significantly underperforming on the WAIS-III sub-tests

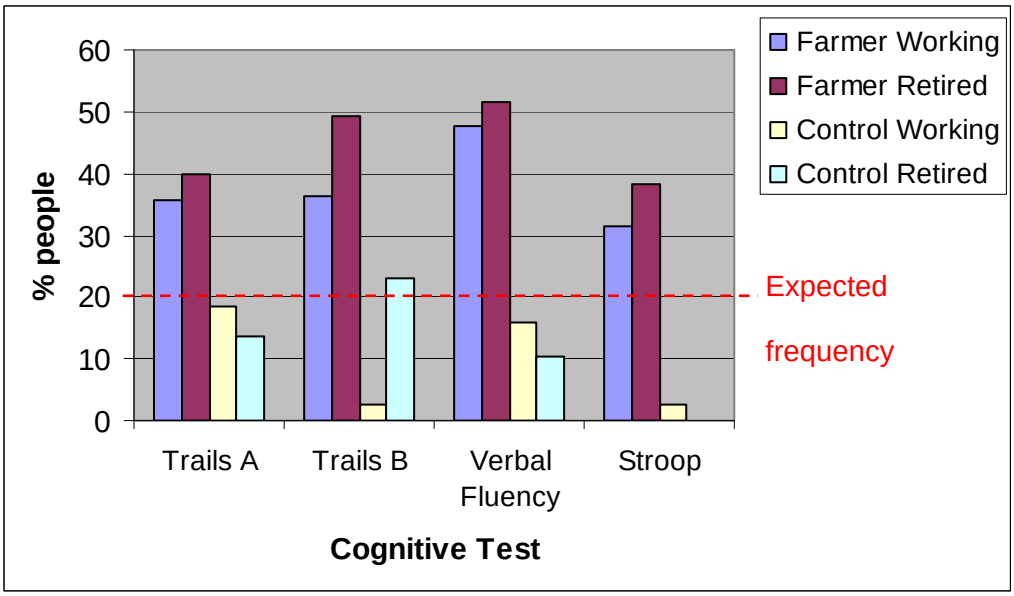


From looking at Figure 3 it appears that overall farmers performed similarly to controls on most measures, however they were more likely to have significant impairments on Digit Span (working memory) and Digit Symbol (response speed) than the police workers. This was true for both working and retired farmers. These findings were further investigated in terms of what one would expect to see in the standardization sample. Again, looking at impairment levels so severe one would only expect to see them in 10% of the standardization sample, a series of binomial tests with .1 set as the proportion of expected impairment were carried out. Results revealed that none of the police workers significantly deviated from the expected 10% frequency and the only significant deviation in the exposed cohort was on digit symbol. That is a significantly higher proportion of both working ($p<.01$) and retired ($p<.001$) farmers were found to have severe impairments on this measure of response speed.

Additional Tests

In addition to the abovementioned tests, further measures of response speed and executive function were collected (Trails A & B, verbal fluency, Stroop). Figure 4 shows the proportion of people in this study who performed with levels of impairment one would only expect to see in 20% of the general population. A cut-off of 20% was selected because the norms for one of the tests (Trail Making A&B) indicated if individuals performed below the 20th percentile but did not provide any further information.

Figure 4: Percentage of people performing at an impairment level only expected in 20% of the population



A series of binomial tests with .2 set as the proportion of expected impairment were carried out revealed that none of the controls significantly deviated from the expected 20% frequency. In contrast both the working and retired farmers were significantly overrepresented at this level of impairment on all four measures (highest p=.02). This indicates that while the control group performed in line with the general population, the OP exposed cohort showed significant impairments on measures of response speed, mental flexibility and strategy making.

Summary & conclusions

In summary the findings above demonstrate that while police workers generally performed in line with standardisation samples, the exposed farmers showed significant deficits in some cognitive domains. The overall findings of this study are the same whether exposed farmers are compared with rural police workers or with published test norms derived from a cross section of healthy adults in the general population. Furthermore, the findings are consistent with the study hypotheses and show deficits on tests of working and general memory, response speed and mental flexibility, but preserved verbal, visuo-spatial, reasoning and general intellectual functioning.