Neuropsychological impact of chronic low-level carbon monoxide exposure in older adults

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Experimental Studies: Acute Low-level CO Exposure

- Studies have typically exposed participants to around 100ppm and durations have been short, lasting a few hours.
- A rise in COHb levels by 3% have been reported to significantly impair driving skills (Wright et al., 1973).
- Deficits in tracking ability and divided attention at COHb levels of 5% (Putz, 1979; Gliner et al., 1983).
- However, other studies have reported no CO-related effects on cognition at COHb level between 5-13% (Roche et al., 1981; Wright & Shephard, 1978; Benignus et al., 1977).

Case Reports: Chronic Low-level CO Exposure

A case series of 7 individuals exposed to low-moderate levels of CO within the home over a period ranging from 3 weeks to 3 years reported:

- Consistent symptoms such as headache and nausea
- Affective disorders such as depression and anxiety
- Memory impairments and motor slowing (Myers et al., 1998).

Neuropsychological improvements were observed however:

- Mild neuropsychological deficits remained in some cases
- Self-reported symptoms such as headache and nausea remained high
- Psychiatric problems such as anxiety and depression commonly persisted.

High Risk Groups

Poisoning severity depends on both human and environmental factors:

- Duration of exposure
- Concentration of CO in the air
- Pre-existing disease (Chiew & Buckley, 2014; Raub & Benignus, 2002).

The very young and older adults are at the highest risk of unintentional CO poisoning (Braubach et al., 2013; Ghosh et al., 2015).

Older adults as a group may also be:

- More susceptible to the effects of CO
- At higher risk from CO exposure within the home from faulty appliances and poor ventilation (Harper & Croft-Baker, 2004).
- Misdiagnosis may be a particular concern within high risk groups such as older adults.

The Current Research: Rationale

A few studies examining CO levels within UK homes report ambient levels above the recommended World Health Organisation guidelines (Croxford et al., 2005a; Croxford et al., 2005b; Croxford et al., 2008; McCann et al., 2013).

- Individuals may be exposed to higher levels of CO in the home than those considered to be safe and that could be detrimental to health.
- A high percentage of the population may be at risk from low-level CO exposures.
- Particular concern in the UK as gas appliances are widely used for heating and cooking (Townsend & Maynard, 2002).
- Currently unclear whether exposure to chronic low levels of CO can cause short term or have long lasting effects on the brain.

Aims and Objectives

Whilst undertaking home visits fire officers report high levels of confusion in older residents who may be at risk of chronic CO exposure.

Aims:

- Examine the extent to which chronic low-levels of CO are present within a sample of homes in Coventry in which older adults are living.
- Determine the associated neuropsychological and physical health effects of chronic low level CO exposure.
- Determine the associated impacts of such exposures on outcomes such as quality of life, falls risk and healthcare use.
- Determine the extent to which intervention by the Fire Service in reducing levels of CO in the home results in measurable changes in functioning over time.

Method: Participants and Procedure

- A sample of 106 older adults (≥60 years) residing in Coventry were recruited via liaison with the West Midlands Fire Service.

During safe and well visits residents ≥60 years were invited to take part in a study investigating the possible health effects of sub-alarm levels of CO within the home.

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Fire Officers re-visited individuals to place the data loggers and CO alarms in the home. Participant Information Sheet and Expression of Interest Form given to sign agreeing to sharing information with, and to be contacted by, the researcher.

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Telephone call from researcher to arrange appointment and answer questions. → Visit from researcher at home. Consent Form. Initial assessments.

↓

Fire Service collect data loggers after 1 month. Data downloaded and combined with health data for analysis

↓

Fire Service revisit homes to provide intervention and place the data loggers at 7 months. Visit from researcher at home. Consent form repeated. Follow up testing .

Method: Measures

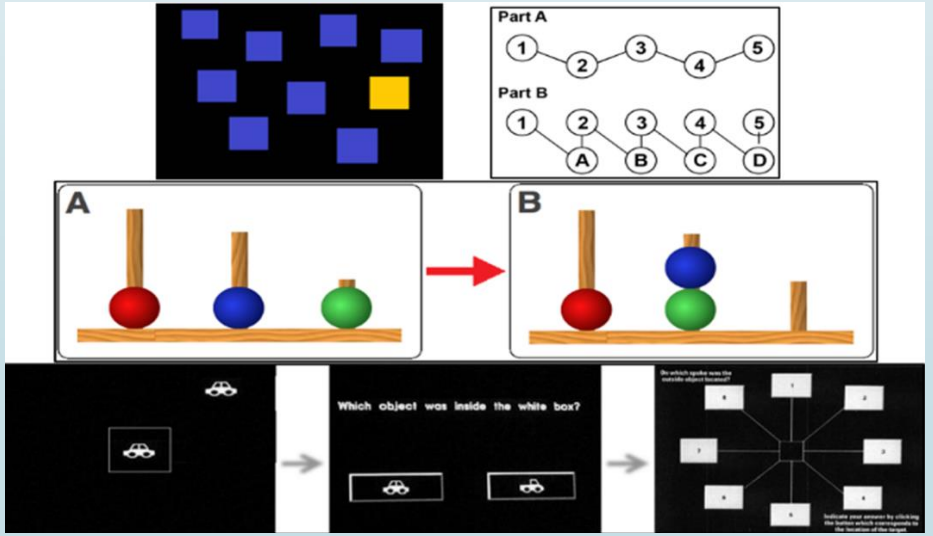
General information:

- Age and Education level
- Smoking status
- Property type/ tenure
- Home appliances
- Heating and cooking methods
- Time spent within the home
- Health and social care use
- Previous falls
- Quality of life
- Symptom checklist
- Physical and psychiatric diagnoses
- Self perceived health

- Levels of CO within the blood (COHb) and breath (ppm).

Neuropsychological Assessments:

- Global cognitive functioning
- Selective, divided, and sustained attention
- Processing speed
- Working verbal/visual memory
- Immediate and delayed recall
- Executive function (planning, problem solving, cognitive flexibility and inhibition)
- Visuomotor speed
- Anxiety and depression



Hypotheses

First phase: initial visit

- H_1 Chronic low-level CO exposure will be associated with impaired cognitive function and increased levels of depression and anxiety.

- H_2 Chronic low-level CO exposure will be associated with negative outcomes such as low quality of life, increased falls risk and higher health and social care use.

Results: Developing a CO Measure

- CO levels fluctuate over the month with readings taken every 5 minutes: total 8065 CO readings

❖ Large amount of zero readings so the **mean**, **median**, **mode** CO level for the majority of participants was around 0.

❖ However, the graphical representation of the data presented a different picture with spikes of CO over the month.

- Total CO over the month was calculated and regression models were developed.

❖ However, using the total CO was unable to separate completely different exposure types in the analyses.

Results: Developing a CO Measure

Figure 1. CO levels over 1-month showing continuous extremely low CO levels. Gas fire and boiler

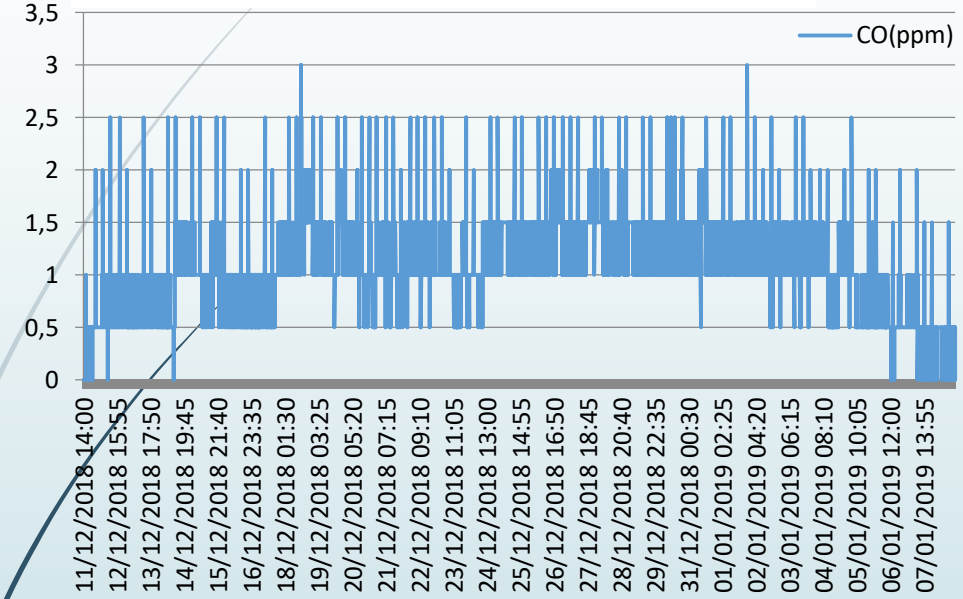
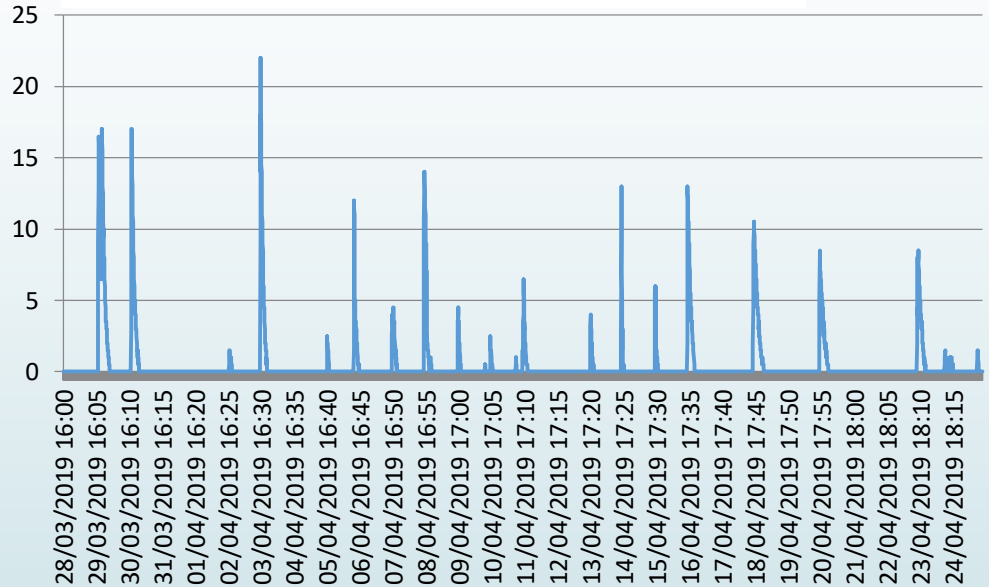


Figure 2. CO levels over 1-month showing higher short lasting CO peaks. Gas fire, boiler and cooker



- Some data revealed a continuous extremely low-level CO exposure for the whole month
- Whereas, other data showed a different pattern of exposure with the majority of CO readings over the month at zero with higher short lasting CO peaks up to around 22ppm.
- Using the total CO was concealing these exposure differences as participants may have had similar CO monthly totals but completely different exposures.

Results: Developing a CO Measure

- CO ranges were developed based both on the range within the collected data and the recommended WHO indoor air quality guidelines (2010).
- The highest CO peak was 29ppm, the two lowest WHO guidelines were used (6ppm for 24 hours and 9ppm for 8 hours).
- The following CO ranges were developed: 0.5-3ppm, 3.5-6ppm, 6.5-9ppm, 9.5-12ppm, 12.5-15ppm, 15.5-18ppm and 18.5-30ppm.
- The final ranges: 0.5-3ppm (n=70), 3.5-6ppm (n=39), 6.5-9ppm (n=25) and 9.5-30ppm (n=15).
- The total CO over the month was separated into the specified ranges (the total CO that fell within each range for each participant) and converted to a percentage.

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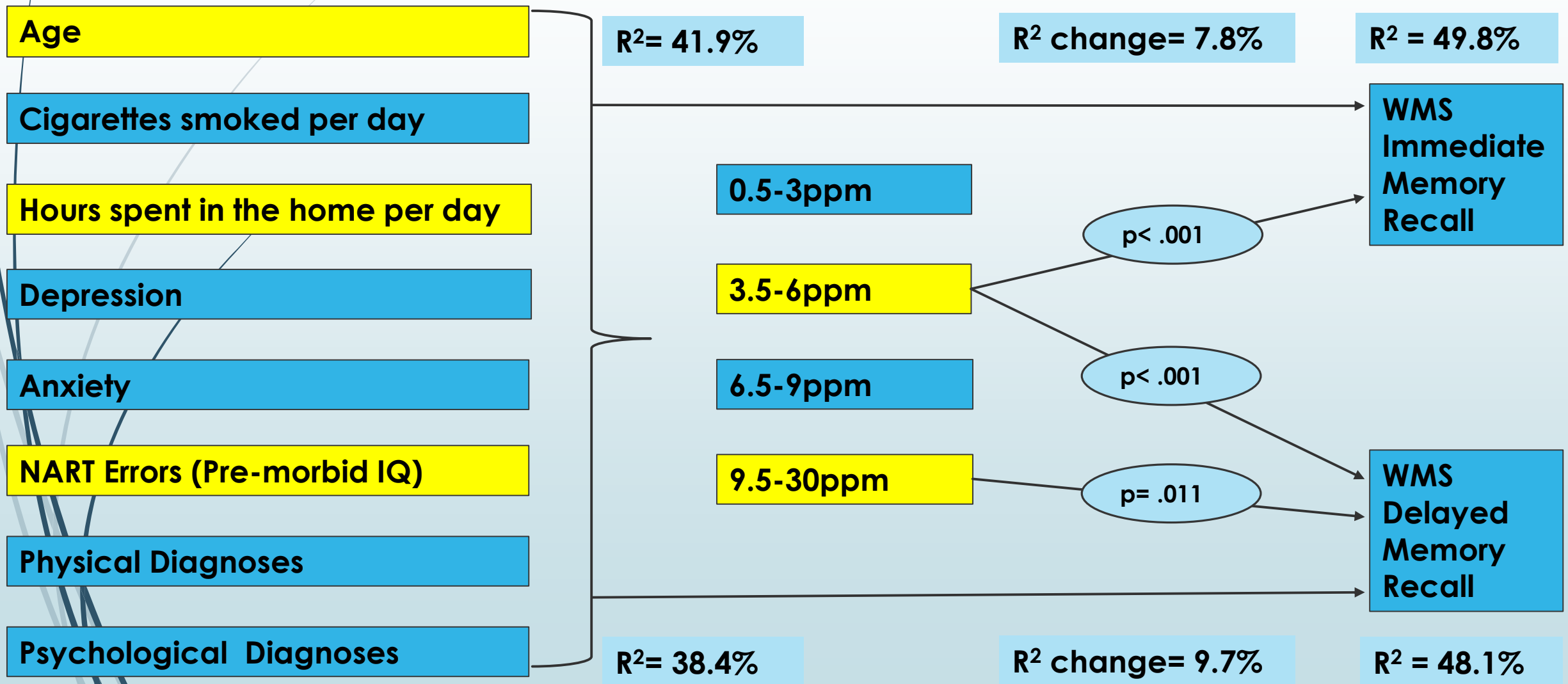
Results: Cognitive Regression Models



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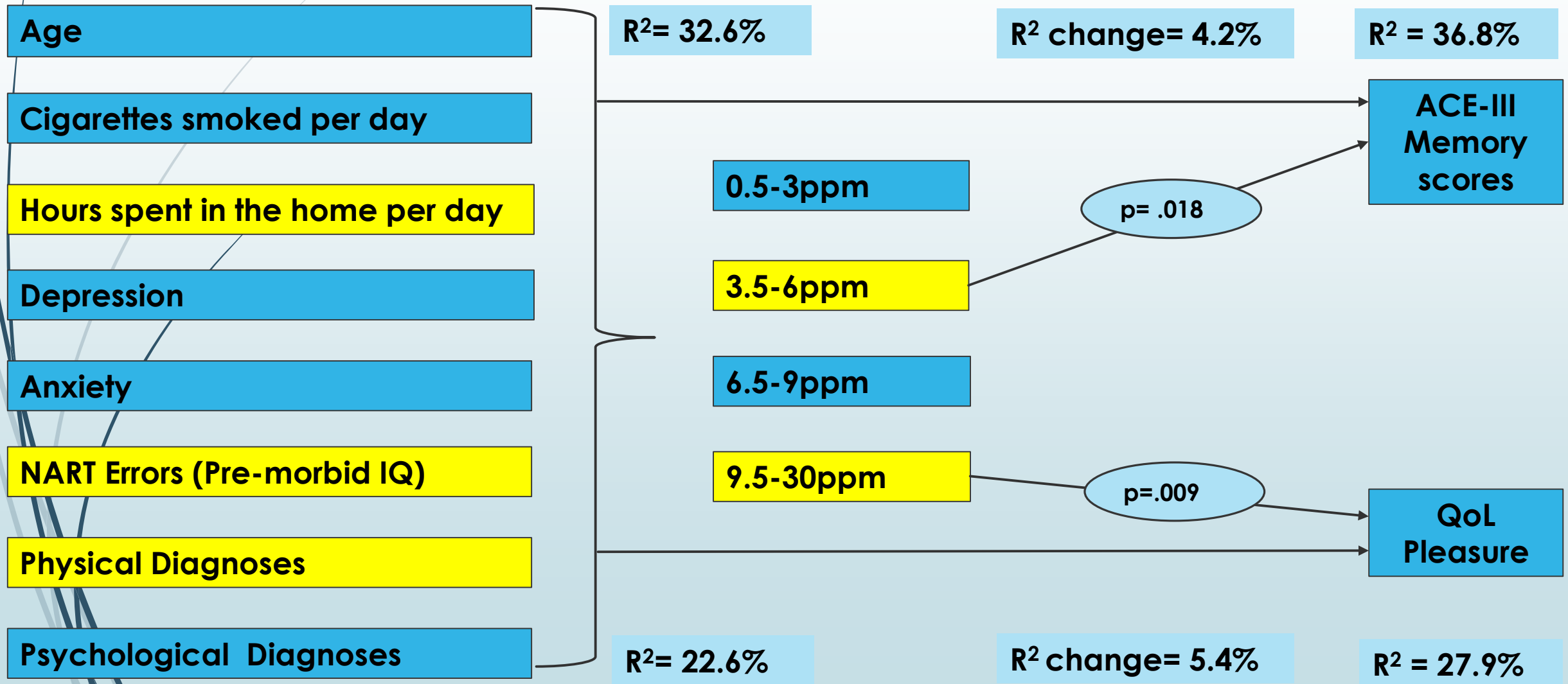
Results: Cognitive Regression Models



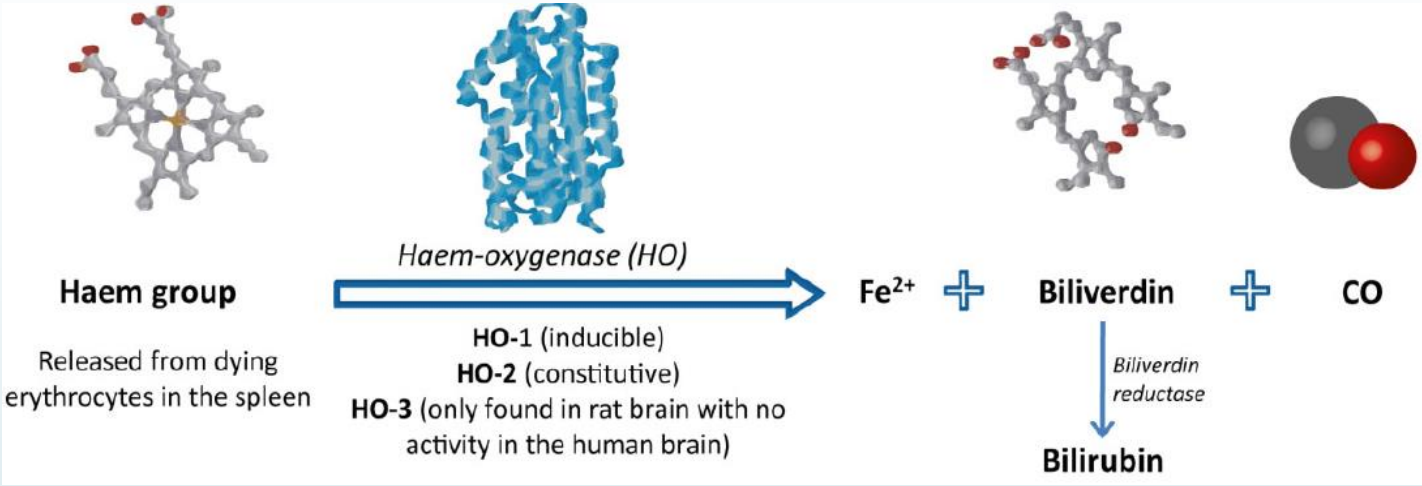
Discussion: Initial Conclusions

Results revealed:

- Immediate and delayed memory recall scores significantly increased with higher CO percentage in the 3.5-6ppm range
- Delayed memory recall and quality of life decreased with greater CO percentage in the 9.5-30ppm range.
- Preliminary results suggest that chronic exposure to extremely low levels of CO may have positive effects on both immediate and delayed memory recall.
- However, chronic exposures to higher levels of CO appear to have a deleterious effect on both delayed memory recall and quality of life.

Discussion: Endogenous CO Production

- The degeneration of haem
- Catalysed by haemoxygenase (HO)
- Converts haem to biliverdin, free iron and CO.



(Queiroga, Vercelli, & Vieira, 2015)

- Involved in various cellular functions. Therapeutic actions include vasodilation, neurotransmission, anti-inflammatory, proliferation and anti-apoptotic factors.
- HO is activated in response to a range of different cellular stress conditions such as ischaemia, hypoxia and inflammation with CO production resulting in neuroprotection.
- Plays a crucial role in cellular maintenance, protection, regeneration and survival.

(for reviews see Mahan, 2012; Queiroga, Vercelli, & Vieira, 2015).

Discussion: Exogenous CO Administration

Physiologic and cytoprotective properties at low concentrations, exogenous administration of low levels of CO for neuroprotection is being explored for therapeutic use.

- Human clinical trials indicate that inhaled low-levels of CO is safe and tolerable (Rosas et al., 2013).
- Inhaled CO as a neuroprotective agent could benefit patients with traumatic brain injury, hypoxic injury, stroke and epilepsy.

The view of CO and its effects on the CNS has typically been negative, however:

- Endogenous CO is crucial for normal brain function.
- Yet CO is also so potentially toxic.
- Dependant upon the dose and duration of exposure.

(for reviews see Mahan, 2012; Queiroga, Vercelli, & Vieira, 2015)

Next Stages

Analyse Health Data:

- GP/ outpatient appointments/ falls/ admissions/social and domestic care/ BP
- Symptom data

Additional information:

- Geographical Region
- Property Type and Tenure
- Appliances within the Home
- Heating and Cooking Methods
- Smoking Status and Smoking Behaviour
- Appliance Service History
- Carbon Monoxide Alarm Ownership

97/106 (91.5%) were non-smokers

- 8/9 smokers smoked in the home

70/106 homes had some CO

- 69/70 (98.6%) gas boiler
- 58/70 (82.9%) gas cooker
- 43/70 (61.4%) gas fire
- 6/70 (8.6%) smoked in home

36/106 homes had no CO

- 35/36 (97.2%) gas boiler
- 17/36 (47.2%) gas cooker
- 24/36 (66.7%) gas fire
- 2/36 (5.6%) smoked in home

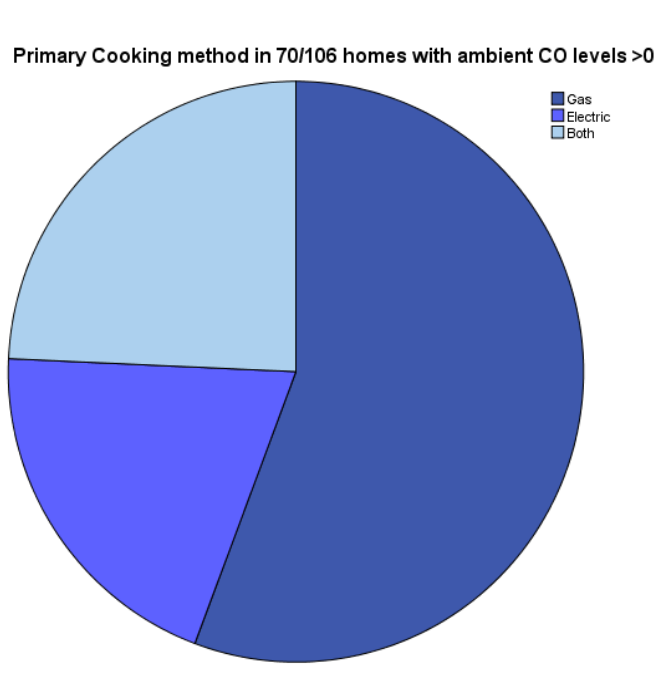
Next Stages

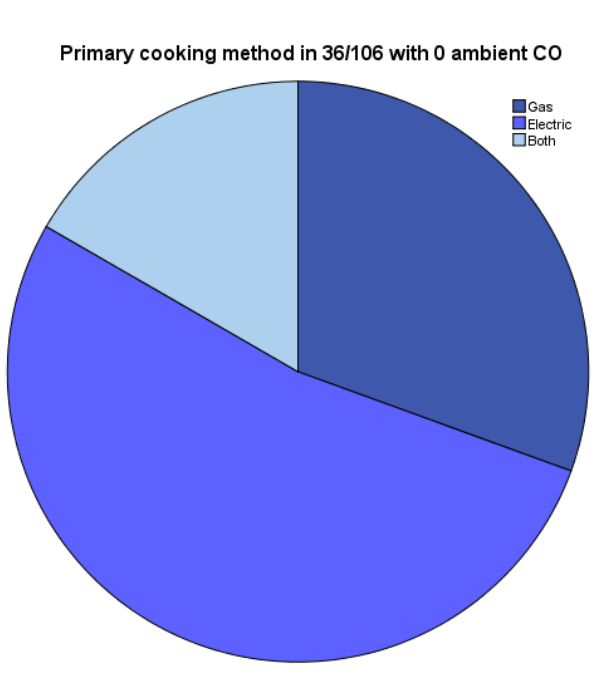
Primary cooking method
70 homes with CO:

- Gas 39/70 (55.7%)
- Electric 14/70 (20.0%)
- Both 17/70 (24.3%)

36 homes with no CO:

- Gas 11/36 (30.6%)
- Electric 19/36 (52.8%)
- Both 6/36 (16.7%)





- Analyse phase 2 data (7 month follow up)

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