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Healthy Buildings Conference & Expo 2018

14 February 2018, London

Indoor environment and workplace productivity: insights from WLP+ project

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We work with Innovate UK

EPSRC Engineering and Physical Sciences Research Council

IEQ and productivity in workspaces

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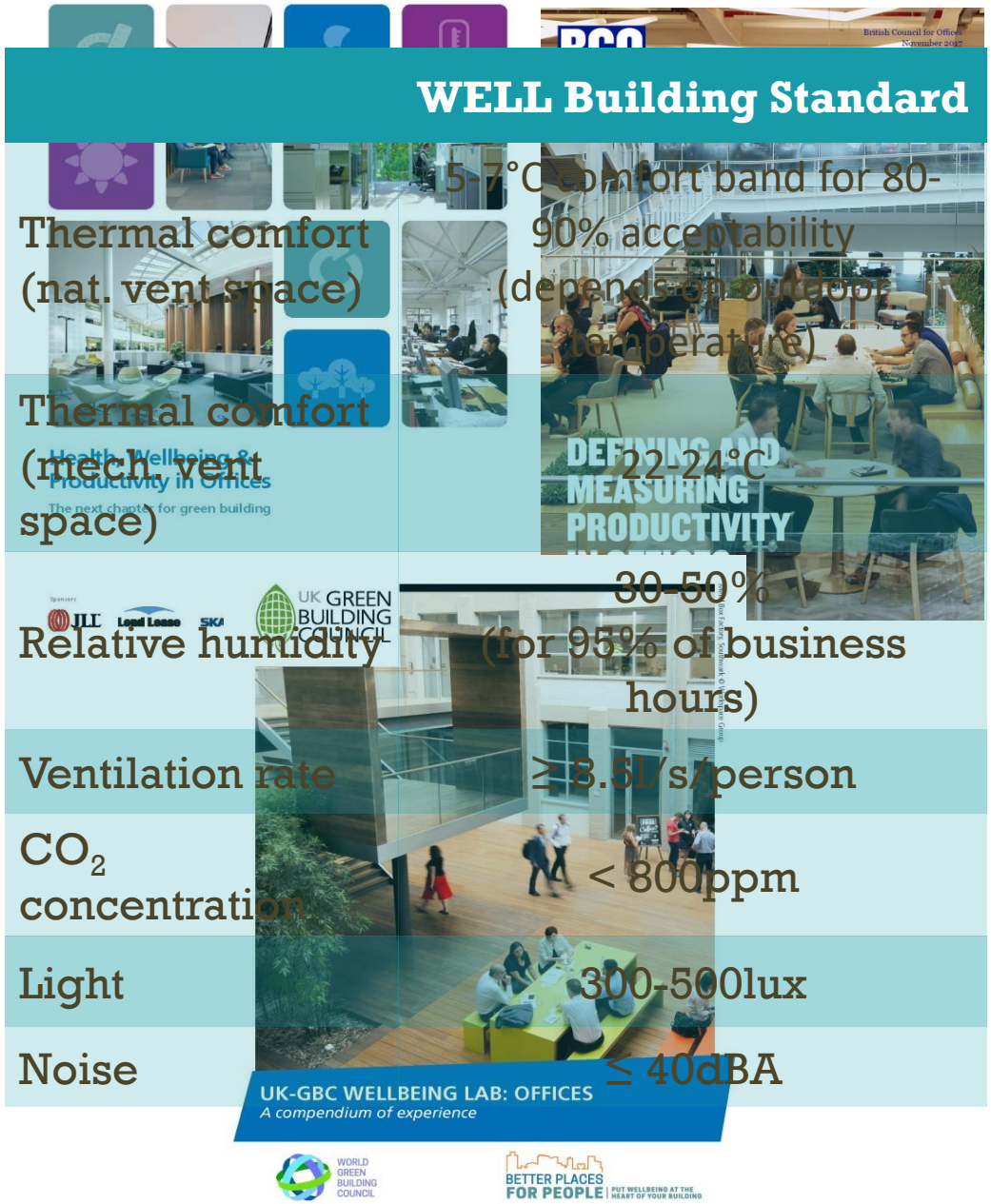
- Indoor environment has a significant influence on our comfort, health and wellbeing, given that we spend 80% - 90% of our time indoors.

- Recently Green Building Councils worldwide have collated evidence linking indoor envrionment with occupant health, wellbeing and productivity in offices.

- Emergence of WELL building standard.



WELL Building Standard	
Thermal comfort (nat. vent space)	5-7°C comfort band for 80-90% acceptability (depends on outdoor temperature)
Thermal comfort (mech. vent space)	22-24°C
Relative humidity	30-50% (for 95% of business hours)
Ventilation rate	≥ 8.5l/s/person
CO_2 concentration	< 800ppm
Light	300-500lux
Noise	≤ 40dBA

Whole Life Performance plus (WLP+)

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- Study presented here is part of WLP+ research project.
- Funded by EPSRC and Innovate UK.
- Project value: £530k, 2016-2019.
- WLP+ aims to:
  - Empirically validate the link between IEQ and staff productivity
  - Test the solution in trial commercial buildings and develop a software-based supervisory control.
- Meta-study of existing data (Innovate UK BPE programme)
- Case study based approach – observation and intervention.

http://www.wlpplus.com/

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Innovate UK BPE programme meta study:
Perceived productivity and indoor environment (BUS survey)

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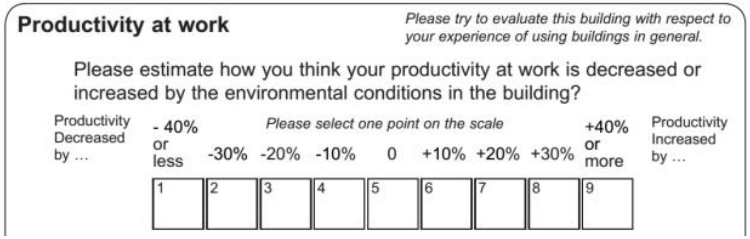


Productivity at work

Please try to evaluate this building with respect to your experience of using buildings in general.

Please estimate how you think your productivity at work is decreased or increased by the environmental conditions in the building?

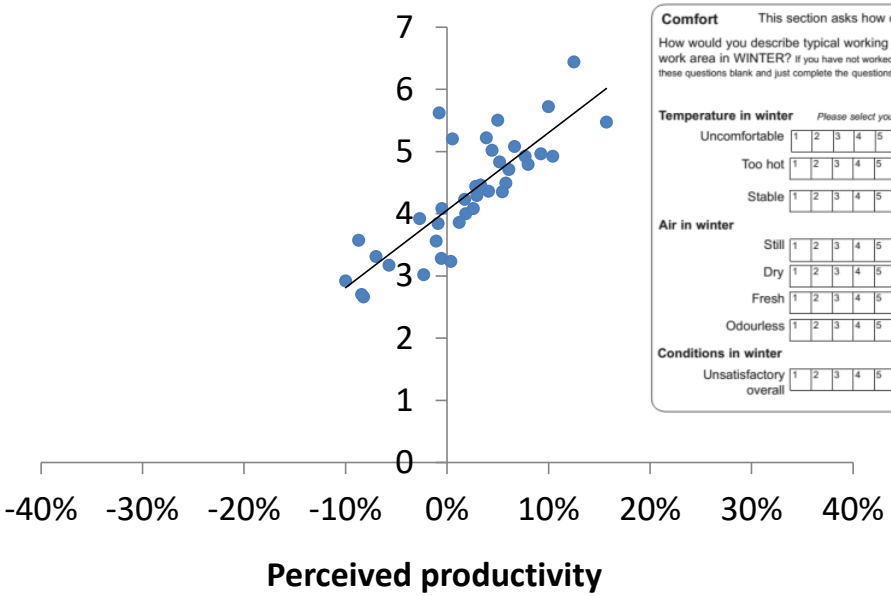
Please select one point on the scale

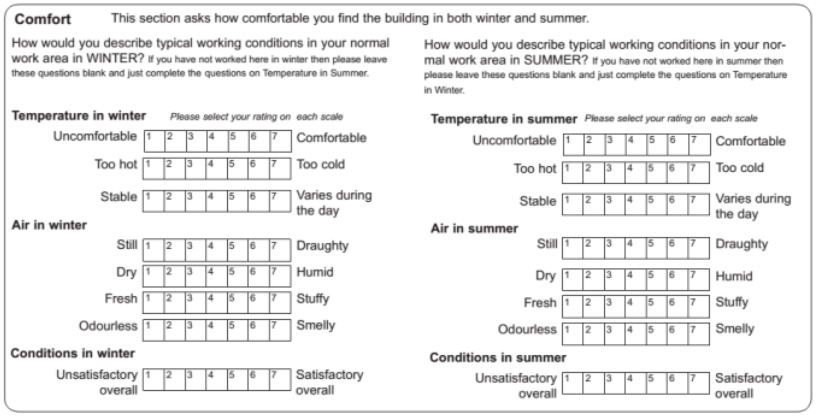
Productivity Decreased by …	- 40% or less	-30%	-20%	-10%	0	+10%	+20%	+30%	+40% or more	Productivity Increased by …
	1	2	3	4	5	6	7	8	9	

Overall air quality in summer

1 – unsatisfactory 7 – satisfactory

n = 38, r = 0.82





Comfort This section asks how comfortable you find the building in both winter and summer.

How would you describe typical working conditions in your normal work area in WINTER? If you have not worked here in winter then please leave these questions blank and just complete the questions on Temperature in Summer.

Temperature in winter *Please select your rating on each scale*

Uncomfortable	1	2	3	4	5	6	7	Comfortable
Too hot	1	2	3	4	5	6	7	Too cold
Stable	1	2	3	4	5	6	7	Varies during the day

Air in winter

Still	1	2	3	4	5	6	7	Draughty
Dry	1	2	3	4	5	6	7	Humid
Fresh	1	2	3	4	5	6	7	Stuffy
Odourless	1	2	3	4	5	6	7	Smelly

Conditions in winter

Unsatisfactory overall	1	2	3	4	5	6	7	Satisfactory overall

How would you describe typical working conditions in your normal work area in SUMMER? If you have not worked here in summer then please leave these questions blank and just complete the questions on Temperature in Winter.

Temperature in summer *Please select your rating on each scale*

Uncomfortable	1	2	3	4	5	6	7	Comfortable
Too hot	1	2	3	4	5	6	7	Too cold
Stable	1	2	3	4	5	6	7	Varies during the day

Air in summer

Still	1	2	3	4	5	6	7	Draughty
Dry	1	2	3	4	5	6	7	Humid
Fresh	1	2	3	4	5	6	7	Stuffy
Odourless	1	2	3	4	5	6	7	Smelly

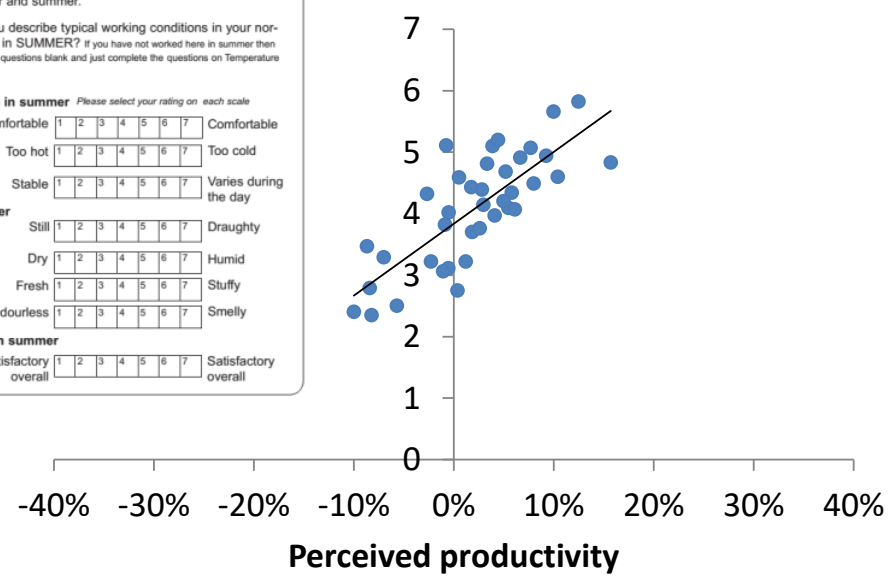
Conditions in summer

Unsatisfactory overall	1	2	3	4	5	6	7	Satisfactory overall

Overall temperature in summer

1 – unsatisfactory 7 – satisfactory

n = 38, r = 0.78

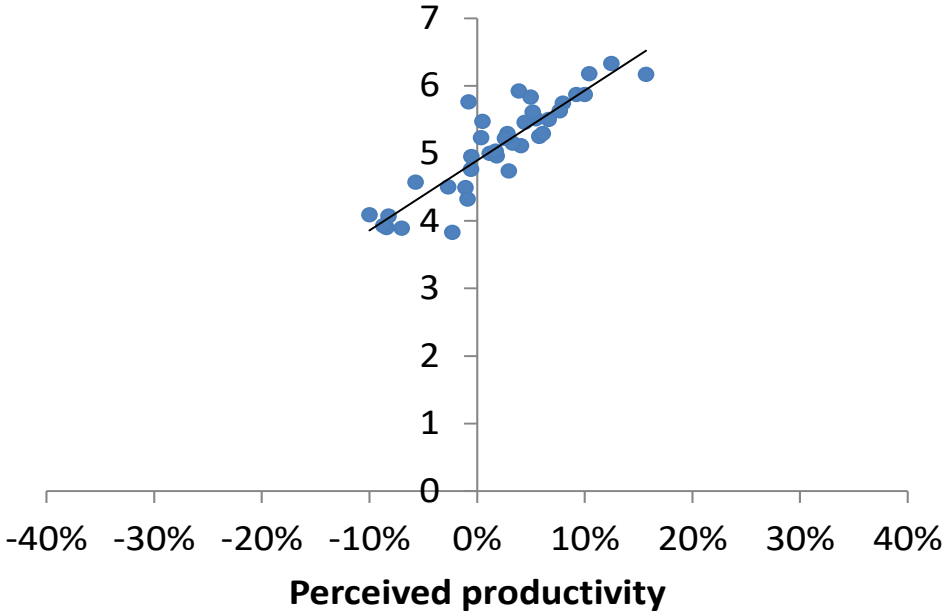


Comfort and health

- Occupant's overall comfort and their perceived health when in the building also had strong, positive correlations with perceived productivity
  - **Overall comfort had the strongest correlation with perceived productivity**

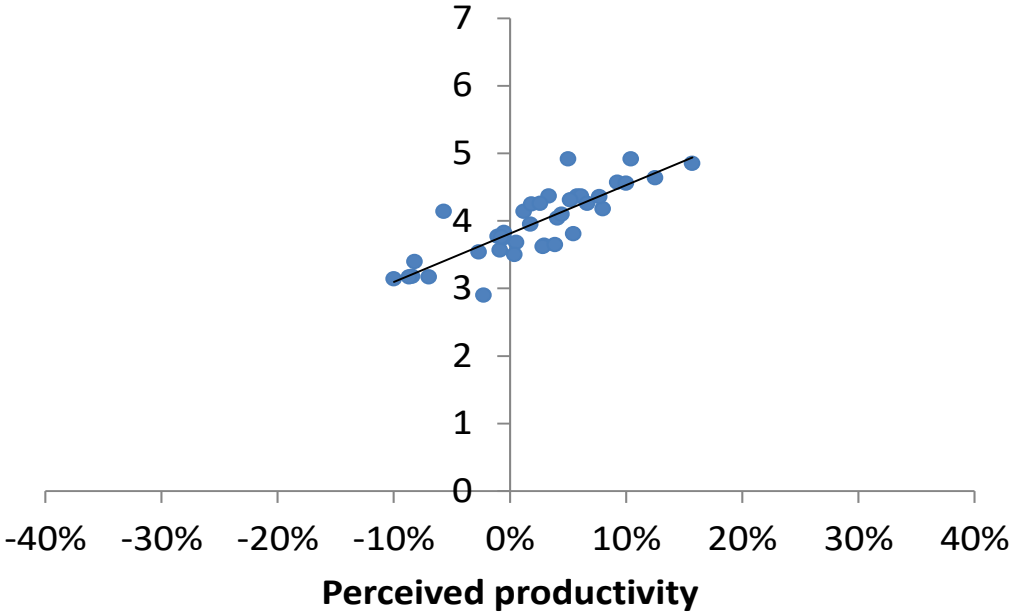
Overall comfort
1 – unsatisfactory 7 – satisfactory

n = 38, r = ***0.89***



Perceived health
1 – less healthy 7 – more healthy

n = 38, r = 0.83



King's College London

WLP+
Whole Life Performance +

- Naturally ventilated building.
- Next to a busy roundabout and train station.
- Student administration and marketing.
- Interesting environment for studying the impact of natural ventilation and air quality.

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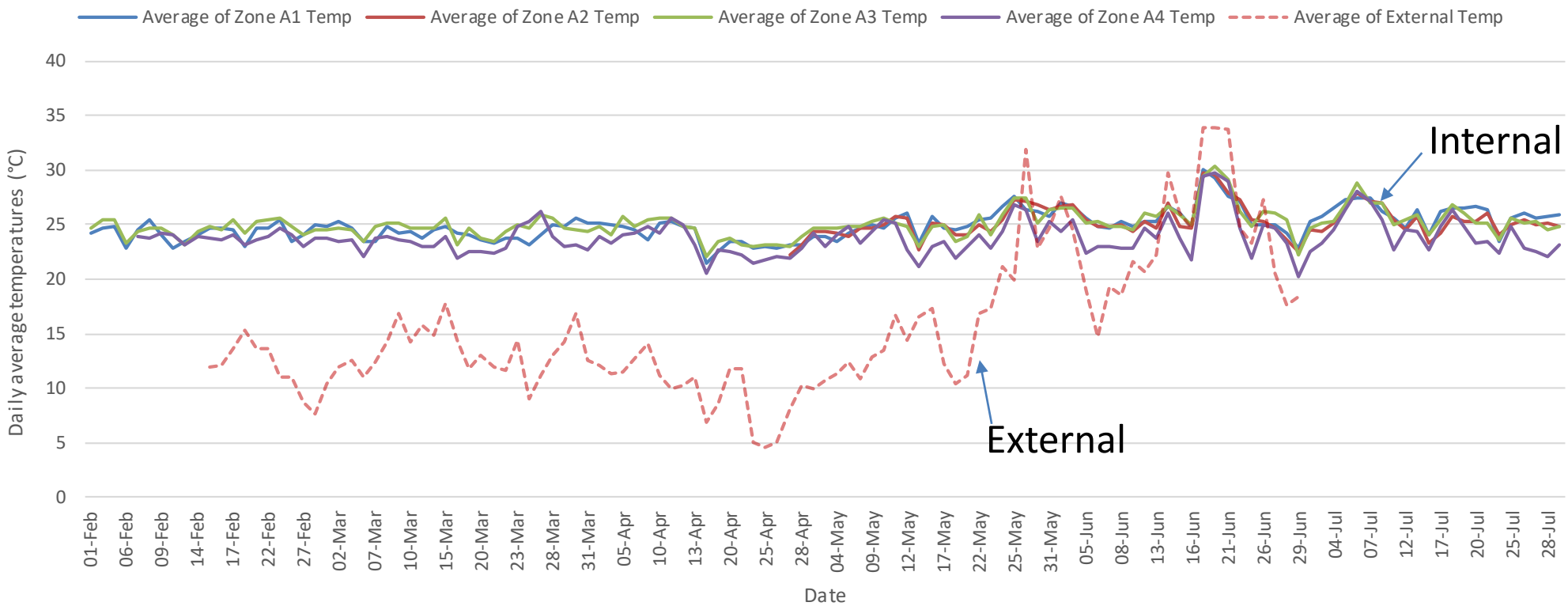
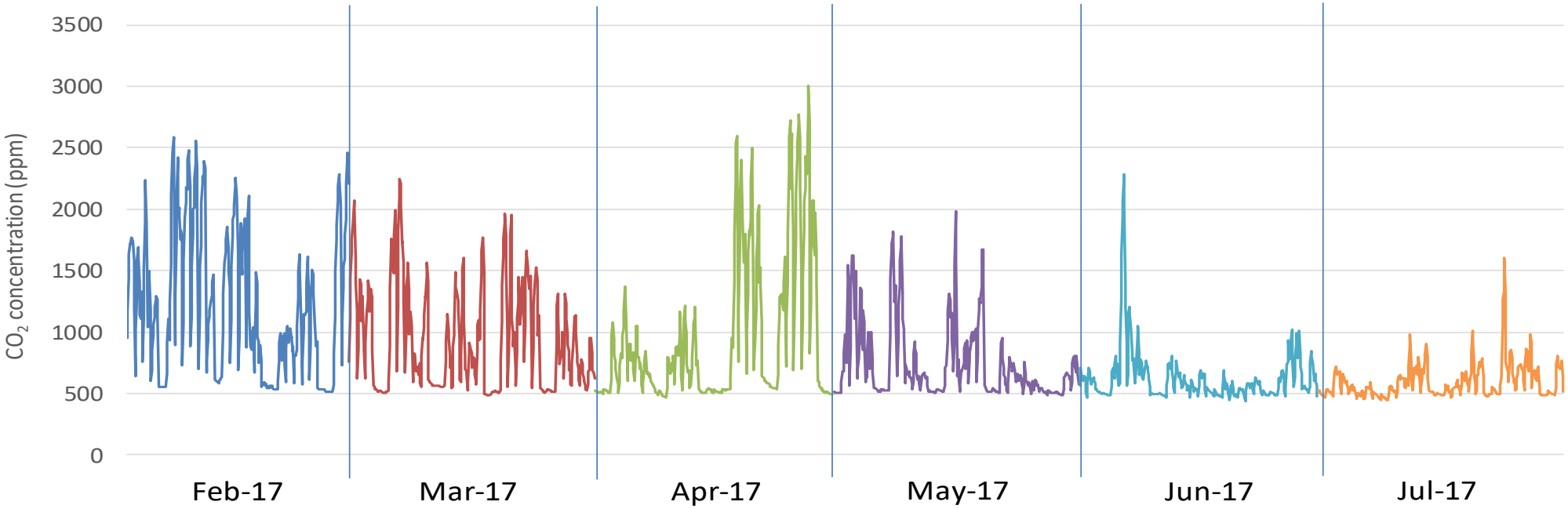
Indoor temperature Occupied hours in weekdays: 08:00-18:00



Temp (°C)	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17
Average temp	24.3	24.3	23.5	25.1	26.0	26.0
Minimum temp	17.7	19.2	18.0	20.4	19.8	19.5
Maximum temp	27.2	27.6	27.1	29.8	31.3	30.0

Indoor CO_2 levels Occupied hours in weekdays: 08:00-18:00



CO_2 (ppm)	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17
Average CO_2	1443	1083	1174	823	673	642
Minimum CO_2	522	512	492	469	431	438
Maximum CO_2	2660	2291	3066	2082	2337	1769

BUS survey: feedback from occupants (n: 77)

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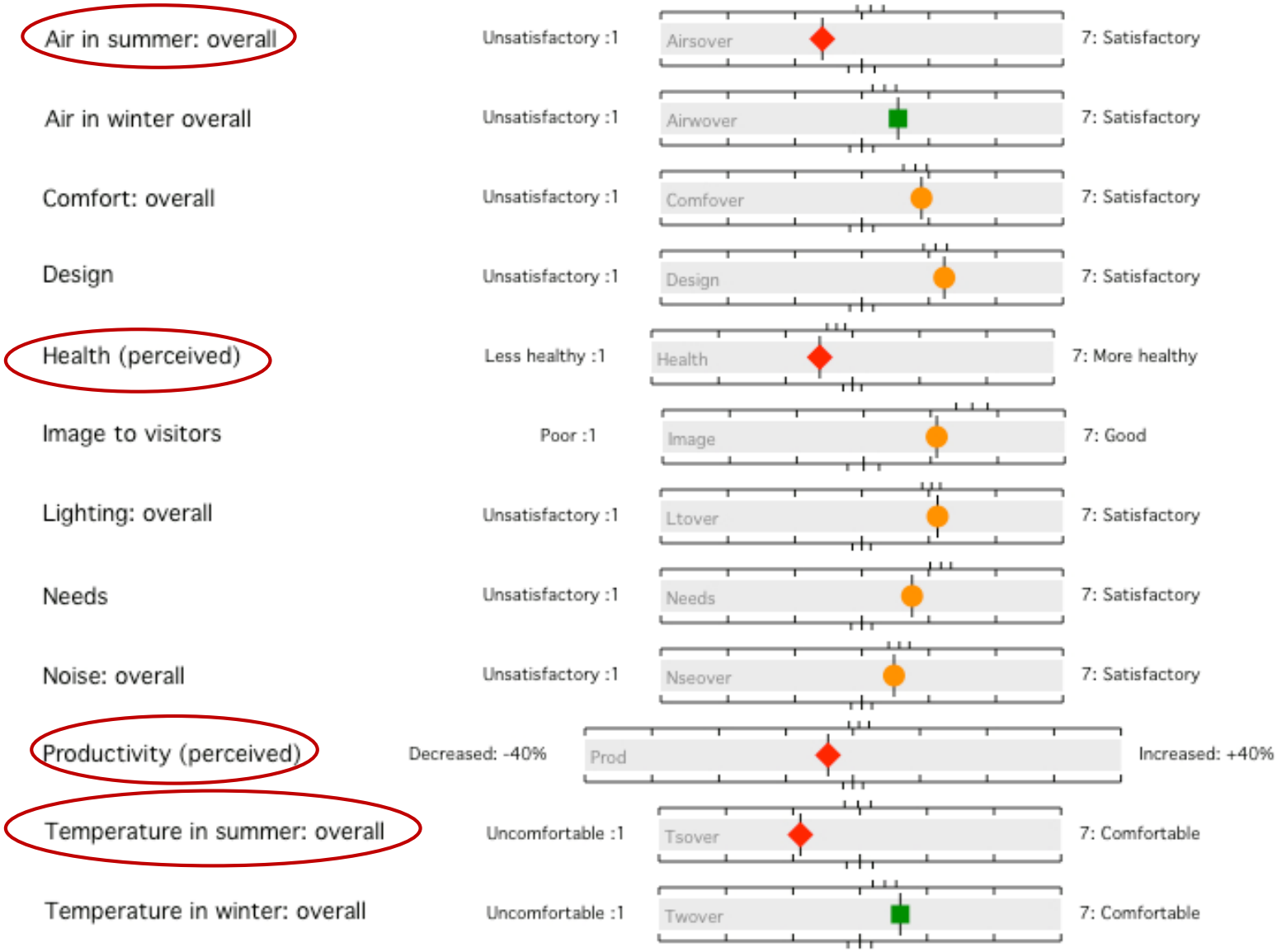
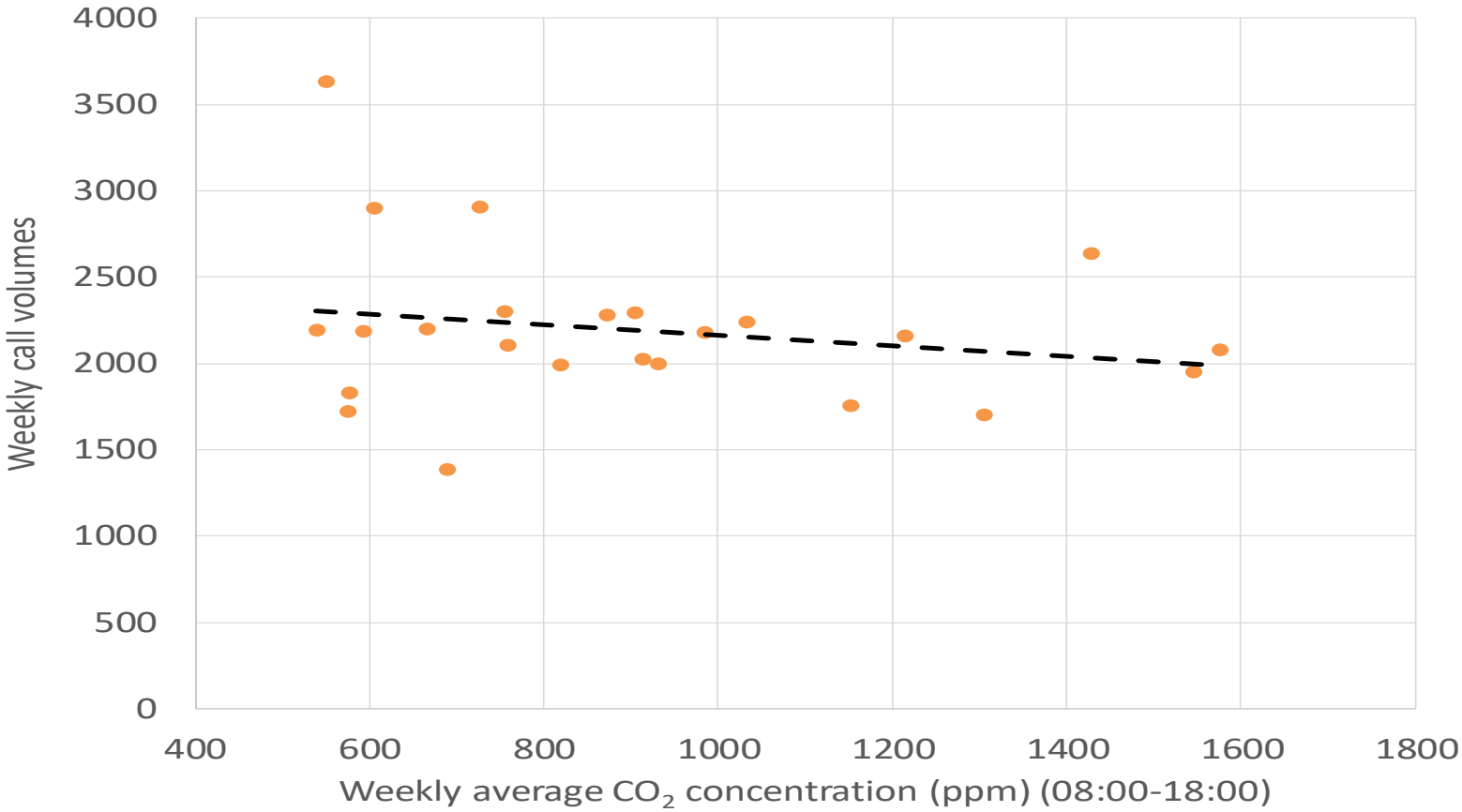


Productivity (Business output metrics)

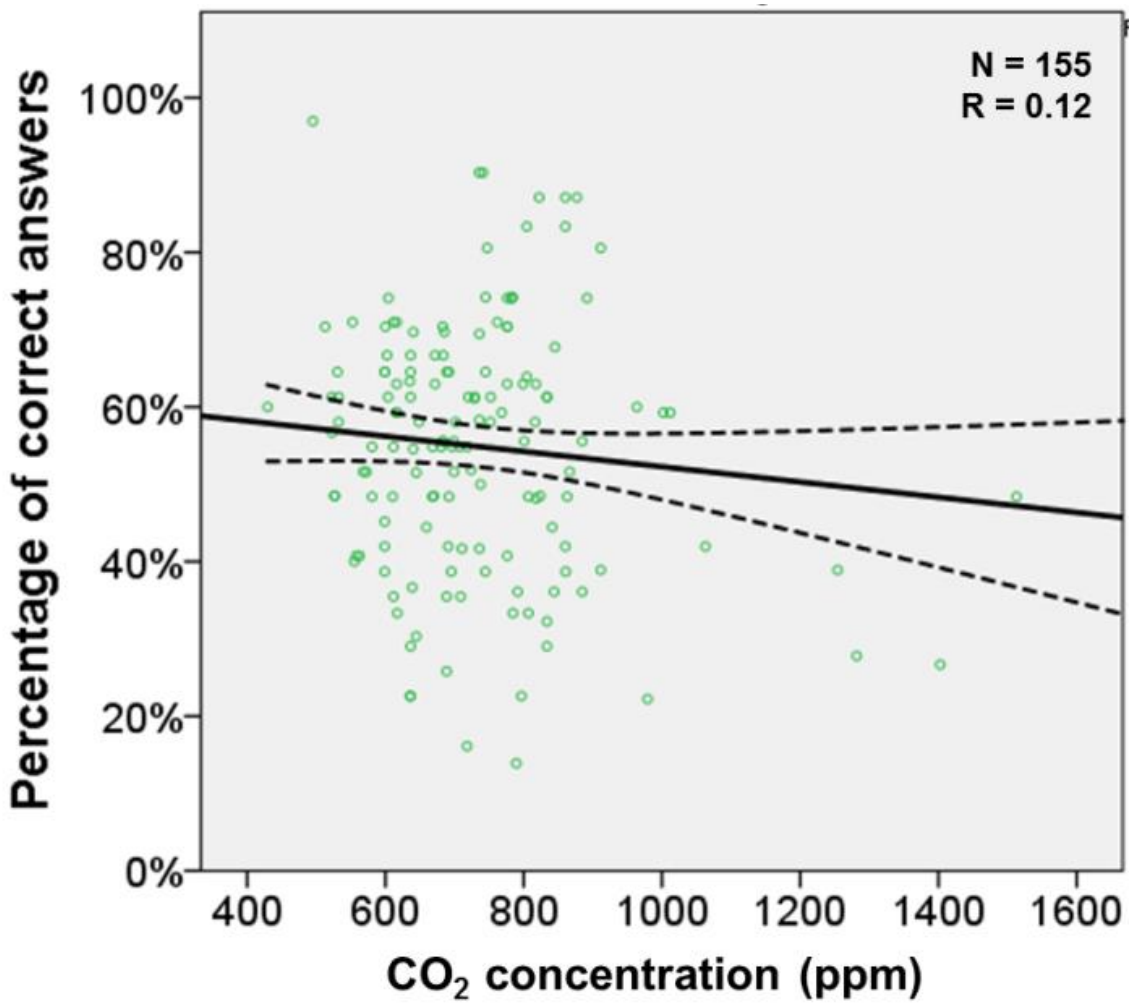
Productivity data	Call volumes
Time period	Weekly: 30Jan – 14Jul 2017
Average emails/calls	Weekly: 2,193



Call volumes and CO_2 levels

Numerical test and indoor CO_2 levels

Number of responses: 155



Summary

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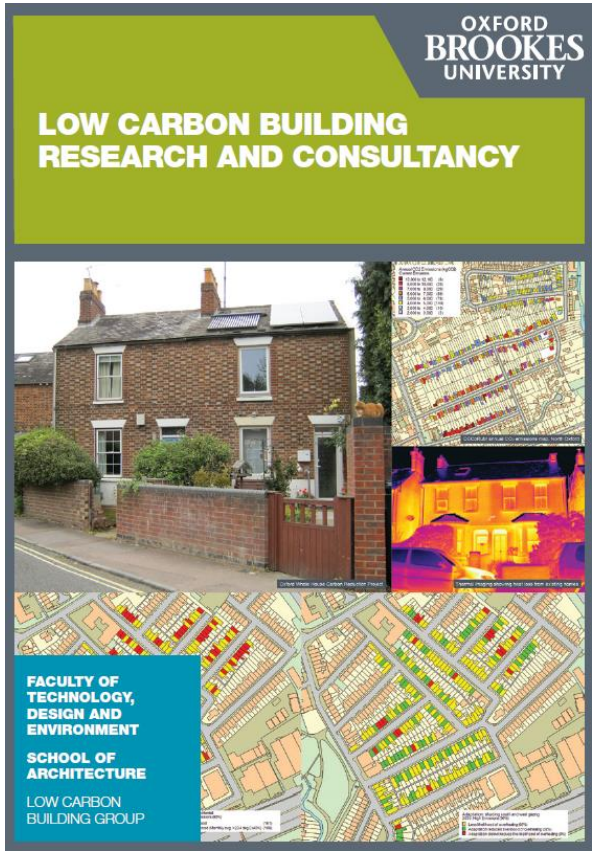
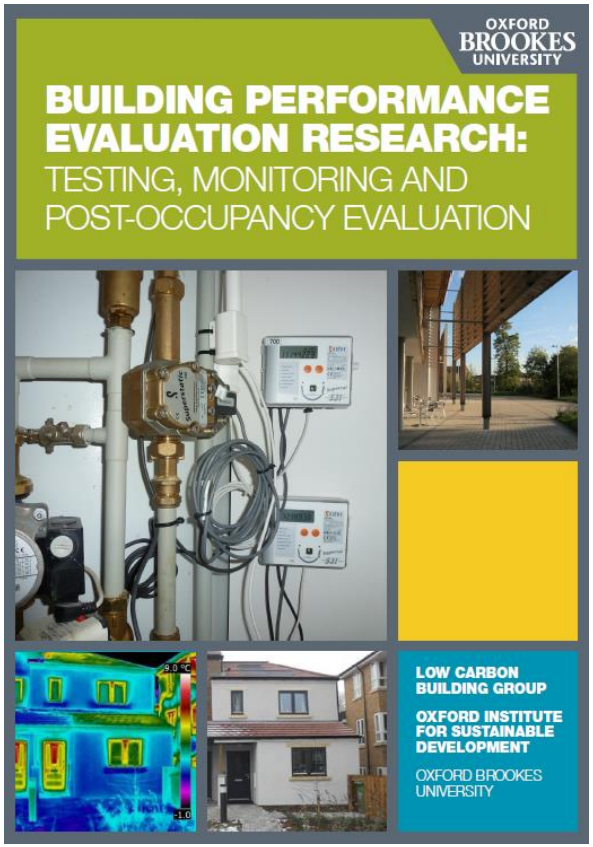
- When occupants were satisfied with their indoor environment (such as indoor temperature, air quality) their perceived productivity was found to increase.
- Non-environmental/functional factors (design, facilities, image to visitors) have a strong impact on perceived productivity.
- WLP+ project is empirically testing the link across work spaces using business output/HR metrics; self-reported (survey) and measured productivity metrics (such as time taken to complete discrete tasks).
- Measured indoor temperature and CO_2 levels in the case study are found to be above the recommended ranges during working hours. There is a link between performance metrics and CO_2 levels.
- Interventions to improve indoor temperature and CO_2 levels should be considered. This is what the WLP+ project is presently focussing on.

Thank you!





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