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The effect of a housing intervention on the quality of the neighbourhood environment

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Contents

Abstract

This report presents the findings of a study to assess the impact of a major housing improvement programme on the quality of the neighbourhood environment in Carmarthenshire, Wales. The study involved the revision and subsequent use of an established residential environment assessment tool (REAT 2.0) to evaluate changes in neighbourhood quality following housing intervention in 282 postcode areas in Carmarthenshire. This is to our knowledge the first study that has conducted detailed neighbourhood quality assessments at multiple time points to examine the wider neighbourhood impacts of a programme to improve housing standards in social housing. The study found that investments in existing housing stock have the potential to improve the outlook of neighbourhoods. Measurable improvements in the overall quality of the neighbourhood environment were observed using REAT 2.0, with the greatest increases being measured in postcodes receiving the most external work to the properties. Methodological and practical limitations of the study are also discussed.

Key Words: Housing intervention; neighbourhood quality; residential environment assessment; REAT 2.0

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The study received ethical approval from the School Research Ethics Committee (SREC) of the Welsh School of Architecture, Cardiff University (EC1306.154).

Introduction

Background

Housing-led renewal programmes have the potential to improve the outlook of neighbourhoods, by both upgrading the physical fabric of housing and acting as a catalyst for wider neighbourhood regeneration (Carley, 1990; Carter, 2012; Cole et al, 2010). The Carmarthenshire Homes Standard (CHS) programme involved wide-scale investments in council-owned homes within the county. Interventions were planned in housing, gardens and the estate environment and it was therefore anticipated that the programme would have the potential to deliver observable improvements in the overall quality of the neighbourhood environment in addition to the properties themselves.

The research aimed to assess the impacts of the housing intervention on the overall quality of the neighbourhood environment, using the revised Residential Environmental Assessment Tool (REAT 2.0). This working paper first reports on the development of the REAT 2.0 instrument and its validation through the research. It then describes the neighbourhood quality assessments that were conducted in a sample of postcodes containing properties due to receive improvement work under the housing improvement programme.

It was expected that the housing intervention would result in measurable improvements in the overall quality of the neighbourhood environment, and that these improvements would be linked to work that contributes to the external appearance of the property and the estate environment in general. It was therefore hypothesised that: (1) there would be an observable increase in overall neighbourhood quality in the assessed postcodes; (2) the observed increases in neighbourhood quality would be greater in postcodes that received more work under the housing intervention programme; and (3) the observed increases in neighbourhood quality would be greater in postcodes that received more work contributing to the external appearance of the property and the estate environment in general.

The revised Residential Environment Assessment Tool (REAT 2.0)

Neighbourhood quality data was collected using the revised *Residential Environment Assessment Tool* (REAT 2.0), an instrument based on a neighbourhood assessment tool developed in 2001 (Dunstan et al, 2005). The tool was amended to facilitate data collection and provide it with a more explicit theoretical structure. This was achieved by shortening and restructuring the instrument according to four distinct dimensions (see Figure 1). The revised REAT 2.0 tool was validated as part of the research. It was found to be a reliable, easy-to-use instrument to assess neighbourhood quality. High levels of inter-rater reliability were

found, with kappa coefficients (κ) of 0.77 or greater for individual categorical items and Spearman's rank correlation coefficients (ϱ) of 0.97 or greater for the overall REAT 2.0 and its constituent component scores. REAT 2.0 was also validated against residents' own perceptions of the neighbourhood through a neighbourhood quality perceptions survey. This showed that the instrument has sound construct and predictive validity. A more detailed description of the development, structure, and validation of REAT 2.0 is provided in Poortinga et al (2016).

Figure 1. Structure and content of the REAT 2.0 instrument.

	Street Level	Property Level
Neighbourhood Condition	*Litter in public space* *Condition of public space* *Vandalism/graffiti in public space*	*Property maintenance* *Garden maintenance* *External beautification*
Natural Surveillance	*View of the street*	*View of windows and doors*
Natural Elements	*Natural elements in public space*	*Trees in front gardens* *Purposively planted vegetation in front gardens*
Miscellaneous (Urban Form)	*Housing type* *Road type* *Road layout* *Car parking* *Recreational space* *Neighbourhood watch sign*	*Space outside front door*

Three of the dimensions (i.e. *neighbourhood condition*, *natural surveillance,* and *natural elements*) contribute to an overall neighbourhood quality score. The fourth *miscellaneous* dimension captures a number of urban form aspects that do not form part of the overall neighbourhood quality score, but are used to characterise the neighbourhoods under assessment. Results relating to these urban form elements are therefore not reported in this paper. REAT 2.0 both covers *public and private spaces* of the neighbourhood environment, i.e. streets and properties (see Figure 1). The *neighbourhood condition* dimension is

intended to capture the quality or condition of public and private spaces (Taylor, 1984; Perkins et al, 1993). The *natural surveillance* dimension is designed to capture the elements of street and property surveillance (Newman, 1972; cozens et al, 2005). The *natural elements* dimension records green elements in both public (e.g. a park or tree-lined road) and private (purposefully planted vegetation in front gardens) spaces (Lee & Maheswaran, 2011).

Methods

Setting and Study Design

The research took place in the three major urban areas in Carmarthenshire (Llanelli, Carmarthen, and Ammanford). All postcodes from these three areas where external CHS interventions were planned but had not yet begun were selected for study. Rural postcodes were not considered for the research due to a lack of concentrated council-owned housing. This amounted to 282 postcodes (approximately 30% of the total number of postcodes with council-owned housing). The selected postcodes comprised 6,807 residential properties, of which 2,932 were council owned. The total number of properties and the number of properties that were council owned in each postcode varied substantially (M=24.2; SD = 16.0 and M=10.4; SD = 9.7 respectively).

All 282 postcodes were subjected to neighbourhood quality assessments using REAT 2.0. The first baseline round of assessment was undertaken between 30 May and 8 August 2012. All postcodes were visited on foot by pairs of observers, using the pen and paper version of the REAT 2.0 instrument (see Appendix 1). The time needed to conduct the assessments depended on the size of the postcode but took an average of 16 minutes to complete (SD = 9). The same postcodes were subject to a second follow-up round of REAT 2.0 assessments two years later, between 25 June and 6 August 2014, using the newly developed REAT 2.0 mobile app. The app was created as part of the research to facilitate data collection, reduce the time needed for data entry, and afford data collection in poor weather. It allowed observers to use tablets and other mobile devices to make neighbourhood quality assessments in the field, and to upload and store their observations digitally. A supporting website was created to collate and display the REAT 2.0 assessments and users of the REAT 2.0 tool are encouraged to upload and share their data on the webpage to produce a UK-wide neighbourhood quality map (http://reat.cardiff.ac.uk).

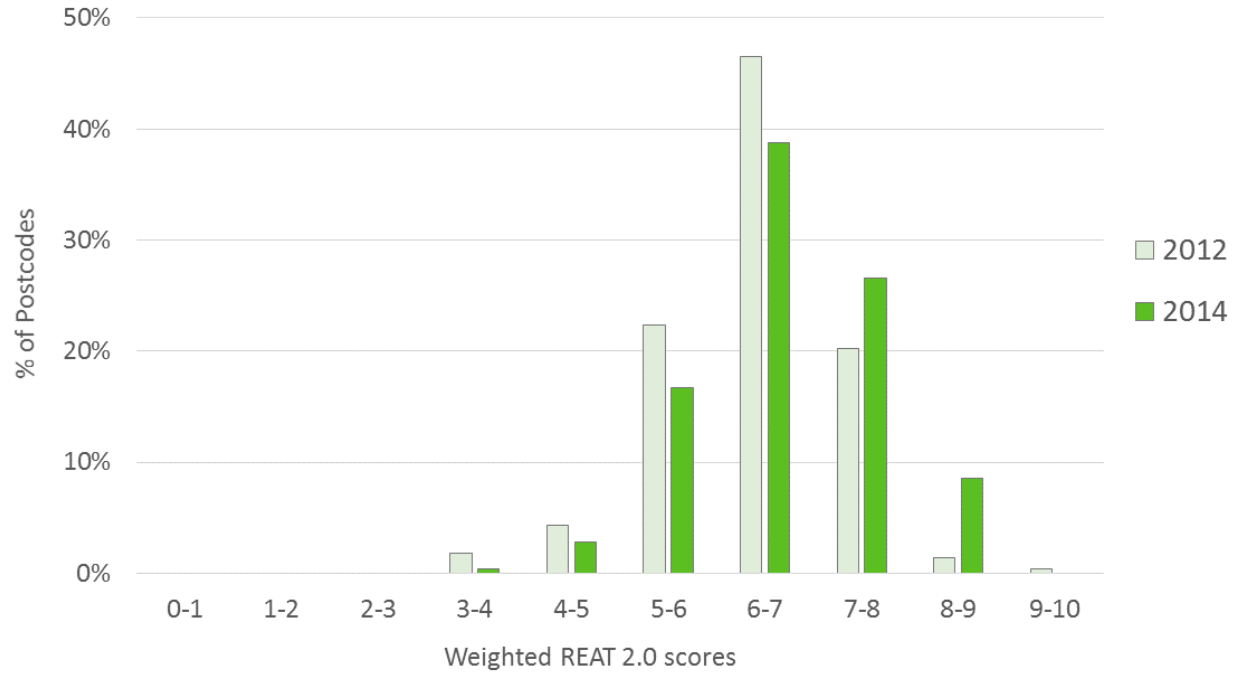
The assessments in the second round took an average 19 minutes to complete (SD = 8). All observers received training prior to conducting the assessments in 2012 and 2014, and had access to a user manual containing instructions, operational definitions and photographs illustrating different grading scales (available at: http://reat.cardiff.ac.uk). The neighbourhood quality scores arising from both rounds of assessment were subsequently weighted using importance judgements derived from the neighbourhood perception survey (see Appendix 2).

Information about the timing, nature and volume of CHS work that was conducted within the postcodes were provided by the Council. In total, 58% of the postcodes contained houses that received some sort of work between the two assessments; 54% of the postcodes contained houses that received internal work (e.g. upgrading of kitchens and bathrooms, wiring, etc.); and 48% of the postcodes contained houses that received external work, most of which (41%) involved security lighting, while only 17% involved garden improvements.

Statistical Analysis

Three sets of statistical analyses were conducted. First, a series of repeated measures Analysis of Variance (ANOVA) was conducted to determine whether there was an overall improvement in neighbourhood quality between the two assessments. The weighted 2012 and 2014 REAT 2.0 overall scores were included as a within-subjects factor, and subsequently the six components scores. Second, a mixed-design ANOVA was conducted to determine whether the observed increases in neighbourhood quality were greater in postcodes that had received more work under the housing intervention programme. The weighted 2012 and 2014 REAT 2.0 scores were included as a within-subjects factor, and the proportion of properties that received any work as a between-subjects factor (with four categories: <25%, 25<50%, 50<75%, and ≥75%). Third, a mixed-design ANOVA was conducted to determine whether the observed increases in neighbourhood quality were greater in postcodes that received more work contributing to the external appearance of the property and the estate environment. The weighted 2012 and 2014 REAT 2.0 scores were included as a within-subjects factor, and the proportion of properties that received any external work as a between-subjects factor.

Figure 2. Distribution of weighted REAT 2.0 scores in 2012 and 2014 (in %).



Results

Did the housing intervention lead to an observable increase in overall neighbourhood quality?

The overall weighted REAT 2.0 scores and its constituent components were used to determine whether the housing intervention resulted in observable improvements in neighbourhood quality. A repeated measures ANOVA showed that there was a medium-sized increase in overall neighbourhood quality between 2012 (M=6.39; SD = 0.87) and 2014 (M=6.73, SD = 0.94), $F(1, 257)=48.758$, $p=0.000$, $\eta^2=0.159$ in the sample postcodes (see Figure 2).

In addition to improvements in overall neighbourhood quality, significant increases in street-level neighbourhood condition were observed between 2012 (M=0.77; SD = 0.13) to 2014 (M=0.82; SD = 0.15), $F(1, 270)=28.350$, $p=0.000$, $\eta2=0.095$. Similarly, substantial increases in property and garden maintenance (property-level neighbourhood condition) were found between 2012 (M=0.60; SD = 0.13) and 2014 (M=0.67, SD = 0.11), $F(1, 262)=159.868$, $p=0.000$, $\eta2=0.379$. Furthermore, a visible improvement was detected in terms of natural elements at the property level between 2012 (M=0.36; SD = 0.17) and 2014 (M=0.42, SD = 0.19), $F(1,272)=48.758$, $p=0.000$, $\eta2=0.159$. As expected, no changes were found for natural elements at the street level, as the council renovation programme did not include such improvements, $F(1,275)=0.002$, $p=0.964$, $\eta2=0.000$, and no changes were detected for street-level and property-level natural surveillance components between 2012 and 2014, $F(1,267)=3.113$, $p=0.079$, $\eta2=0.012$ and $F(1,271)=0.005$, $p=0.943$, $\eta2=0.000$ respectively.

Were the observed increases in neighbourhood quality greater in postcodes that received more work under the housing intervention programme?

The proportion of properties that received interventions within a postcode varied substantially across the included postcodes. This was due to the timing of the working programme and the number of council properties in each postcode. Our second hypothesis, that the observed increases in neighbourhood quality would be greater in postcodes that received more work under the housing intervention programme, was based on the assumption that the likelihood of observing visible signs of improvement at a postcode level would increase with the proportion of properties within a postcode receiving work. The weighted REAT 2.0 scores for the postcodes were therefore compared according to four intervention rate bands. The groups comprised of <25%, 25<50%, 50<75%, and ≥75% of properties receiving *any* intervention within the period of assessment. Table 1 presents the mean differences (M) and their standard errors (SE) for the weighted REAT 2.0 scores between 2012 and 2014 for the four groups. As expected, a greater increase in neighbourhood quality was observed in the postcodes with the highest rate of intervention (above 75%) as compared to the other postcodes. However, the intervention rate x neighbourhood quality assessments interaction was not statistically significant, $F(3,254)=0.936$, $p=0.424$, $\eta 2=0.011$.

Table 1. Difference in weighted REAT 2.0 scores by proportion of postcode receiving any measure, any external measure, and any internal measure between 2012 and 2014.

% of properties receiving measures	**Any Measure**			**External Measure**			**Internal Measure**		
	M	SE	N	M	SE	N	M	SE	N
< 25%	.34	.06	182	.33	.05	189	.32	.05	211
25 < 50%	.30	.14	42	.34	.16	39	.48	.18	25
50 < 75%	.32	.22	17	.34	.22	15	.63	.35	8
≥ 75%	.67	.27	17	.73	.28	15	.56	.30	14

Note: M=mean difference; SE=standard error; N = number of postcodes

Were the observed increases in neighbourhood quality greater in postcodes that received more external work under the programme?

The third hypothesis posited that the observed increases in neighbourhood quality would be greater in postcodes that received more work contributing to the external appearance of the property and the estate environment in general (i.e. external wall insulation, garden improvements, or security lights).

Textbox 1: Remote neighbourhood quality assessments using *REATview*

An online REAT 2.0 facility (*REATview*) was developed that uses *Google Street View* to allow remote neighbourhood quality assessments. The *REATview* tool is based on the REAT 2.0 mobile app, and included access to *Google Street View* panoramic images, as well as further help options with direct access to operational definitions and supporting photographs for each question (see http://reat.cardiff.ac.uk).

Two trained auditors conducted remote assessments of a subsample (n = 102) of postcodes using *REATview*. The assessments were used to calculate the inter-rater reliability (IRR) of *REATview* and were compared to on-site assessments of the same postcodes using the original REAT 2.0 instrument.

The results of the study were mixed. While the IRRs were strong for the property-level assessments, they were weaker for the street-level. The correlations between the remote and on-site assessments were generally moderate in size, which may be part explained by temporal differences in the assessments and the different viewpoints afforded by *Google Street View* images and site visits. Furthermore, remote assessments took longer to complete than on-site assessments. Overall, the results suggest that remote assessments using *REATview* in its current form should be used with care.

For further details, see Appendix 3.

The postcodes were again subdivided into four intervention rate bands, i.e. with <25%, 25<50%, 50<75%, and ≥75% of properties receiving external work within the period of assessment. Table 1 presents the mean differences (M) and their standard errors (SE) for the weighted REAT 2.0 scores between 2012 and 2014 for the four groups. As expected, a greater increase in neighbourhood quality was observed in the postcodes with the highest rate of intervention (above 75%) as compared to the other postcodes. Again, the intervention rate x neighbourhood quality assessments interaction was not statistically significant, $F(3,254)=1.133$, $p=0.336$, $\eta 2=0.013$.

Discussion

The study provided evidence on the impacts of the housing intervention on the overall quality of the neighbourhood environment, using detailed neighbourhood quality assessments of 282 postcodes that were conducted in 2012 and 2014. The key results of the study are that there are measurable, medium-sized improvements in the overall quality of the neighbourhood environment following investments under the housing intervention programme. The study further found that neighbourhood quality increases were the greatest in postcodes with the highest rate of intervention, and the postcodes that received the most external work under the housing intervention programme. Although the latter effects were not statistically significant, they are suggestive of a dose effect but with insufficient statistical power to confirm.

The lack of statistical significance highlights one of the study weaknesses as a result of the timing and scaling back of some improvements during the intervention period. The eventual scheduling of the interventions meant that by the time the post-test round of REAT 2.0 assessments were conducted, 42% of the audited postcodes (118 out of 282) had not yet received any measures. This was further compounded by a downsizing in the number of postcodes containing interventions affecting the outside of the property, where differences in REAT 2.0 scores were most likely to be detected. Investments in the gardens and estates work package were reduced substantially after a pilot showing that the costs involved were prohibitive. This meant that less work was done to the gardens and estates and in fewer communities. The final number of postcodes with properties receiving substantial work were therefore small, affecting the study's ability to detect the relatively small effects that were expected. In the sample of postcodes where REAT 2.0 assessments had been conducted, only 17% of postcodes (48 out of 282) contained properties that received any garden improvements, the intervention measure expected to have most impact on REAT 2.0 scores. Similarly, only 6% of postcodes (n = 17) contained properties that received external/cavity wall measures and no postcodes/properties received new windows within the intervention period. Although 41% of postcodes (n = 117) contained properties that received security lighting, the effects of these improvements on neighbourhood quality assessments are likely to be small.

Furthermore, as the percentage of council properties within postcodes varied significantly, the proportion of properties in renovated postcodes that received interventions also varied. This is likely to have affected the programme's ability to have a concentrated impact at a postcode level. Table 1 demonstrates that renovated postcodes rarely involved the majority of properties within them, limiting the potential to observe an overall impact at the

neighbourhood level. The number of intervention measures installed within a single property varied considerably (from 1 to 9 measures), with over a quarter of properties having received only a single measure within the period of the study. These issues are expected to have limited the potential to observe changes in neighbourhood quality at a postcode level, reducing the power of the study to detect statistically significant differences in REAT 2.0 scores, particularly when comparing the impact of intervention types.

Conclusion

The study reported in this paper has shown that investments in existing housing stock have the potential to improve the outlook of neighbourhoods. In particular, the study found an observable improvement in the overall quality of the neighbourhood environment, with substantial increases in street level and property level neighbourhood condition and natural elements at the property level. Despite a number of shortcomings relating to difficulties conducting evaluations of existing practical interventions, this is to our knowledge the first study that has conducted detailed neighbourhood quality assessments at multiple time points to examine the wider neighbourhood impacts of a programme to improve housing standards in social housing. REAT 2.0 proved suitable for assessing areas undergoing housing improvements and would be useful to evidence the wider area level economic and social benefits of housing improvement work.

References

Carley, M. 1990. *Housing and Neighbourhood Renewal Britain's New Urban Challenge*. London: Policy Studies Institute, University of Westminster.

Carter, T. 2012. Neighbourhood improvement: the role of housing and housing institutions. In: *International Encyclopedia of Housing and Home.* Oxford: Elsevier Publishing, pp. 67-72.

Charreire, H., Mackenbach, J. D., Ouasti, M., Lakerveld, J., Compernolle, S., Ben-Rebah, M., McKee, M., Brug, J., Rutter. H., & Oppert, J. M. 2014. Using remote sensing to define environmental characteristics related to physical activity and dietary behaviours: a systematic review (the SPOTLIGHT project). *Health & Place*, 25, 1-9

Cole, I., Foden, M., Robinson, D., & Wilson I. 2010. *Interventions in Housing and the Physical Environment in Deprived Neighbourhoods. Evidence from the New Deal for Communities Programme.* London: Department for Communities and Local Government.

Cozens, P. M., Saville, G., & Hillier D. 2005. Crime prevention through environmental design (CPTED): a review and modern bibliography. *Property Management*, 5, 328-356.

Dunstan, F., Weaver, N., Araya, R., Bell, T., Lannon, S., Lewis, G., Patterson, J., Thomas, H., Jones, P., & Palmer, S. 2005. An observation tool to assist with the assessment of urban residential environments. *Journal of Environmental Psychology*, 25, 293-305.

Lee, A. C. K., & Maheswaran, R. 2011.The health benefits of urban green spaces: A review of the evidence. *Public Health*, 33, 212-222.

Newman, O. 1972. *Defensible Space*. New York: Macmillan.

Perkins, D. D., Wandersman, A., Rich, R. C., & Taylor, R. B. 1993. The physical environment of street crime: Defensible space, territoriality and incivilities. *Journal of Environmental Psychology*, 13, 29-49.

Poortinga, W., Calve, T., Jones, N., Lannon, S., Rees, T., Rodgers, S. E., Lyons, R. A., & Johnson, R. 2016. Neighborhood Quality and Attachment Validation of the Revised Residential Environment Assessment Tool. *Environment and Behavior*, 0013916516634403.

Taylor, R. B., Gottfredson, S. D., & Brower, S. 1984. Block crime and fear: Defensible space, local social ties, and territorial functioning. *Journal of Research in Crime and Delinquency*, 21, 303-331.

Appendix 1: The REAT 2.0 instrument

REAT 2.0 audit instrument	Street name: _____ Number of Properties: _____ Postcode: _____ SOA code: _____	Auditor: _____ Date: _____ Start time: _____ Finish time: _____

Housing and Road Type (Miscellaneous)	
1. Housing type	a) Detached b) Semi-detached c) Terraced d) Flats e) Mixed
2. Road type	a) A Road b) B Road c) C/local Road
3. Road layout	a) Closed cul-de-sac b) Open cul-de-sac c) No-through road d) Through road

Street-Level Observations

Miscellaneous

4. How are cars mainly parked?

- ☐ On street, one side
- ☐ On street, both sides
- ☐ Predominantly public courts
- ☐ Predominantly off street private parking
- ☐ Mixed (on street and private)
- ☐ Can't tell

5. Any recreational space *(inc. non-green)* **that children could play on?**

- ☐ Yes
- ☐ No

Natural Surveillance

6. Can you get a clear view of the whole street and houses?

- ☐ Yes
- ☐ No

Natural Elements

7. Does any of the following apply? *(tick all that apply)*

- ☐ The road is tree lined
- ☐ There are other purposively planted trees in public spaces
- ☐ There is purposively planted vegetation in public spaces
- ☐ There is a view of the natural environment *(countryside, mountain, sea)*
- ☐ There is a view of a park/green area *(man made)*

Neighbourhood Condition

8. How littered are the streets?

- ☐ No litter or refuse
- ☐ Predominantly free of litter and refuse except for some small items
- ☐ Widespread distribution of litter and refuse with minor accumulations
- ☐ Heavily littered with significant accumulations

9. What is the general condition of public spaces?

- ☐ Excellent *(mint condition, one minor fault)*
- ☐ Good *(good except minor isolated repairs)*
- ☐ Mixed *(mix of well and poorly maintained items)*
- ☐ Poor or very poor *(obvious and significant neglect)*

10. How much vandalism/graffiti is present on both public spaces and private properties?

- ☐ None
- ☐ Some *(2 or less small occurrences)*
- ☐ Moderate *(many small or up to one significant occurrence)*
- ☐ Extensive *(large areas of small or more than one significant occurrence)*

Miscellaneous

11. Any neighbourhood watch signs? *(on houses or lampposts)*

- ☐ Yes
- ☐ No

Observations:

Property-level observations

Miscellaneous

12. What is the nature of the space immediately outside front doors? *(Count)*

	With clear barriers impeding entry	*Without clear barriers impeding entry*
Private		
Shared with neighbour(s)		

Public (footpath/ street/ public area)_____

Natural Surveillance

13. Can you get a clear view of ground floor windows or doors from the street?

Yes, can be CLEARLY seen

_____

No, can not be CLEARLY seen

_____

Natural Elements

14. Trees in front gardens that are obvious from road?

Yes_____

No_____

15. Houses with purposively planted vegetation? *(including healthy pots and baskets)*

Yes_____

No_____

Can't tell_____

Neighbourhood Condition

16. How well maintained are properties from the outside? ***(Count) (Look at roof, windows, doors, walls, fascias, and guttering and front garden/yard)*** (*specify if any of the properties are not residential*)

Well *(mint condition)*

_____

Minor damage *(few, small and easy repairs)*

_____

Moderate *(DIY, isolated repairs)*

_____

In need of repair *(Structural attention)*

_____

In desperate need of repair *(extensive refurbishment) (include any clearly derelict or vacant property and land)*

_____

Can't tell_____

17. How well cared for are properties' front gardens or spaces?

Tended fronts *(cared for regularly)*

_____

Slightly neglected/ indifferent *(slightly overgrown, small items of litter, no signs of anything)*

_____

Significantly neglected and/or littered *(significantly overgrown, considerable litter)*

_____

No fronts_____

Can't tell_____

18. Properties with some sort of external beautification? *(pots, garden furniture, decorative items)*

Yes_____

No_____

Can't tell_____

Observations:

Appendix 2: The scoring and weighting of REAT 2.0

This appendix describes how the six core REAT 2.0 components and overall REAT 2.0 scores are calculated from the street-level and property-level observations, and how they can be weighted by importance judgements from residents.

Scoring of REAT 2.0

The overall REAT 2.0 score is calculated by adding the scores of the six core components, creating a scale ranging from 0 to 10. The six components are coded so that higher scores represent a greater presence of the construct. Table 2 shows the items that make up each of the six REAT 2.0 components and their loadings attached to the different rating categories.

The *street-level items* are used to make general observations of the postcode. The *street-level neighbourhood condition* component is calculated by adding together the score loadings for each item contained within it. This includes items 8 (litter in public space), 9 (condition of public space), and 10 (vandalism/graffiti in public space). Together, the three items form a scale from 0 to 3. The *street-level natural surveillance* component reflects the score assigned to item 6 (view of the street), which is scored either 0 or 1 according to whether a clear view is present or not. The *street-level natural elements* component is calculated by counting the number of natural elements present in the postcode (item 7). Each natural element (such as vegetation, or a view of a park or natural environment) receives a loading of 0.2, creating a scale ranging from 0 to 1.

The *property-level items* require the observers to count the number of properties exhibiting a certain feature, so that each postcode under assessment will have a total number of properties for each item (e.g., X properties with and Y without external beautification). Each item is converted into a scale ranging from 0 to 1 using the loadings listed in Table 2. A score of 0 reflects that all properties or gardens received the lowest rating and a score of 1 reflects that all properties or gardens received the highest rating. The overall score for the *property-level neighbourhood condition* component is calculated by adding the loaded scores for all the items contained within it. This includes items 16 (property maintenance), 17 (garden maintenance), and 18 (external beautification). Together, the three items form a scale from 0 to 3.[1]

[1] The score for the property maintenance item is calculated as follows: (1.00 × number of properties with 'well' maintained ratings + 0.67 × number of properties with 'minor damage' ratings + 0.33 × number of properties with 'moderate' ratings + 0.00 × number of properties with 'in need of repair' or 'in desperate need of repair' ratings)/number of properties in the postcode. The garden maintenance score is calculated similarly: (1.00 × number of gardens with 'tended fronts' ratings + 0.50 × number of gardens with 'slightly neglected' ratings + 0.00 × number of gardens with 'significantly neglected'

Table 2. Items and loadings used to calculate the components and overall REAT 2.0 scores.

	Street level			Property level		
Component	**Item[(1)]**	**Category**	**Loading**	**Item[(1)]**	**Category**	**Loading**
Neighbourhood Condition	**Litter (Q8)**	No litter or refuse	**1.00**	**Property maintenance (Q16)**	Well	**1.00**
			0.67		Minor damage	**0.67**
		Predominantly free of litter /refuse	**0.33**		Moderate	**0.33**
					In need of repair/ desperate need of repair	**0.00**
		Widespread distribution of litter/refuse	**0.00**			
		Heavily littered				
	Condition of public space (Q9)	Excellent	**1.00**	**Garden maintenance (Q17)**	Tended fronts	**1.00**
		Good	**0.67**		Slightly neglected fronts	**0.50**
		Mixed	**0.33**			**0.00**
		Poor or very poor	**0.00**		Significantly neglected fronts	
	Vandalism/ graffiti (Q10)	None	**1.00**	**External beautification (Q18)**	Yes	**1**
		Some	**0.67**		No	**0**
		Moderate	**0.33**			
		Extensive	**0.00**			
Natural Surveillance	**View of the street (Q6)**	Yes	**1**	**View of windows and doors (Q13)**	CAN be seen clearly	**0**
		No	**0**		CAN NOT be seen clearly	**1**
Natural Elements	**Natural elements (Q7)**	Tree lined	**0.2**	**Trees in front gardens (Q14)**	Yes	**1**
		Other trees	**0.2**		No	**0**
		Vegetation	**0.2**		Can't tell	**0**
		View natural environment	**0.2**	**vegetation in front gardens (Q15)**	Yes	**1**
					No	**0**
		View park	**0.2**		Can't tell	**0**

Note: [(1)] Item numbers in the table refer to the items in the REAT 2.0 survey instrument.

The *property-level natural surveillance* component reflects the proportion of properties within the postcode of which the ground floor windows and doors can be seen clearly from the street, forming a scale from 0 to 1. For the *property-level natural elements* component, the *trees in front gardens* score reflects the proportion of properties within the postcode that have trees in their front garden, and the *purposively planted vegetation in front gardens* score reflects the proportion of properties within the postcode that have purposively planted

ratings)/number of front gardens in postcode. The external beautification score simply reflects the proportion of properties within the postcode that have some sort of external beautification.

vegetation (other than trees) in their front garden. The 'trees' and 'purposively planted vegetation' in front gardens scores are then averaged to create a score from 0 to 1.

Weighting of REAT 2.0

Adding the scores of the six components creates an overall REAT 2.0 score ranging from 0 to 10. This is an '*unweighted score*', which means that the assessments have not been weighted according to their importance as perceived by residents. A '*weighted*' REAT 2.0 score can be created based on importance judgments attached to the different elements of the six components.

Table 3. Mean importance and ratios for different neighbourhood quality elements and associated REAT 2.0 components.

Component	Item	How important is it to have the following in your street?	Mean[(1)]	Ratio[(2)]
Neighbourhood Condition (SL)	Litter (Q8)	Being litter-free	3.62	1.49
	Condition of public space (Q9)	Well-maintained public spaces and pavements	3.55	1.46
	Vandalism/graffiti (Q10)	Being vandalism-free/ being graffiti free	3.63	1.49
Natural Surveillance (SL)	View of the street (Q6)	A clear view of most of the street and houses	2.72	1.11
Natural Elements (SL)	Natural elements (Q7)	Trees and greenery in public spaces/ A view of a natural environment/ A view of a park or green area	2.96	1.21
Neighbourhood Condition (PL)	Property maintenance (Q16)	Well-maintained houses	3.38	1.38
	Garden maintenance (Q17)	Well-maintained gardens	3.23	1.32
	External beautification (Q18)	People decorating their gardens	2.74	1.12
Natural Surveillance (PL)	View of windows and doors (Q13)	A good view of windows and doors from the street	2.85	1.17
Natural Elements (PL)	Trees/vegetation in front gardens (Q14/15)	People having trees and other vegetation in front gardens	2.44	1.00

Note [(1)] The reported mean using response scales: 0 "Not at all important" to 4 "extremely important"; [(2)] The ratio was calculated relative to the least important aspect of "people having trees and other vegetation in front gardens" (M=2.44).

The importance judgements were derived from *Neighbourhood Quality Survey* conducted among Carmarthenshire residents in 2014 (n = 1,054), featuring questions on neighbourhood quality that corresponded with REAT 2.0 items. The survey established the level of perceived importance of the different elements by asking '*How important is it to have the following in your street?*' The response scale was coded to range from 0 "Not at all important" to 4 "extremely important". An '*importance ratio*' was calculated using the smallest importance rating (which was for trees/vegetation) as the denominator. Table 3 illustrates the

weighted ratios for each REAT 2.0 element, according to their perceived importance.[2] These ratios are used to calculate weighted components and the overall weighted REAT 2.0 score, ranging from 0 to 12.75. In order to make the weighted REAT 2.0 score comparable to the unweighted one, the weighted score can be 'rescaled' to 0 to 10 by dividing it by 1.275.

[2] In certain cases the perception survey used multiple questions to ascertain the level of importance attached to a single REAT 2.0 item. The importance rating for these items were then combined by averaging them. For example, the neighbourhood quality survey asked about vandalism and graffiti separately, but the REAT 2.0 survey instrument collects data on levels of vandalism and graffiti in a single item (question 10), so the results from the two perception survey measures were combined to contribute to the overall weighted REAT 2.0 score.

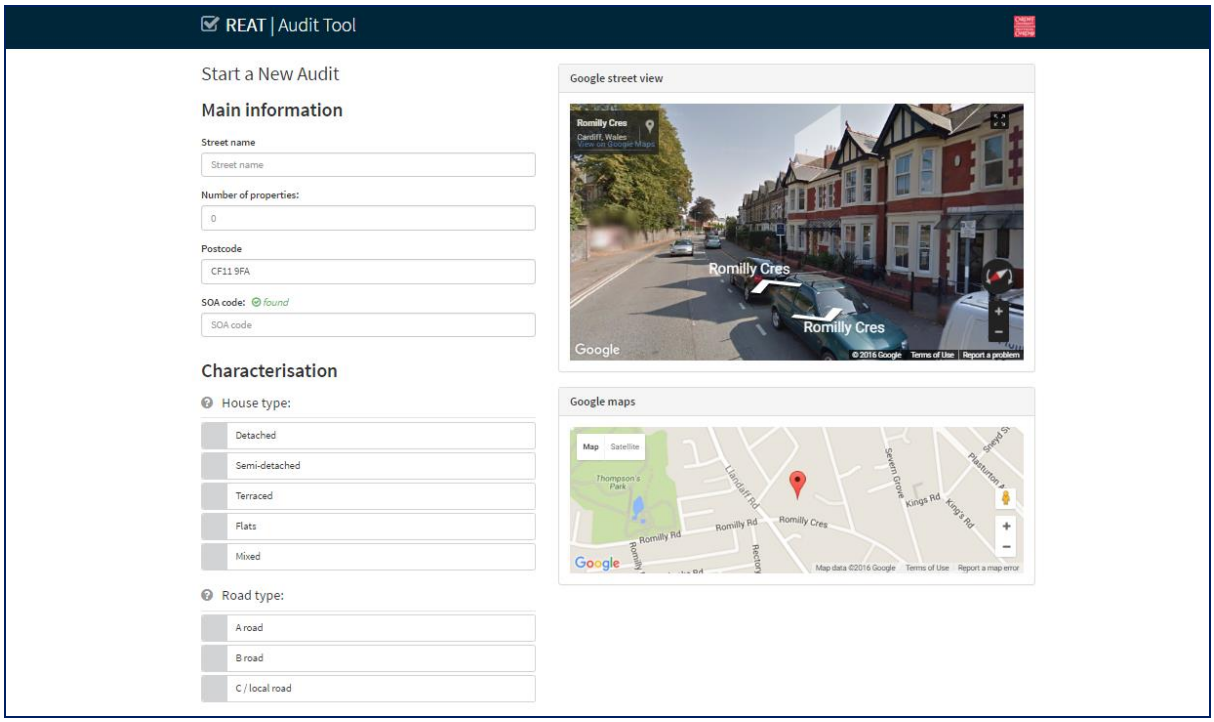
APPENDIX 3 The Remote REAT 2.0 feasibility study (*REATview*).

An exploratory study was conducted to examine the feasibility of conducting REAT 2.0 assessments remotely, removing the need for an assessor to visit the area of investigation. The study involved the development of an online REAT 2.0 facility (*REATview*), which uses *Google Street View*™ panoramic images to enable REAT assessments to be made. A sample of postcodes from the current study were assessed remotely by two assessors. The assessments were used to calculate the inter-rater reliability (IRR) of *REATview*. *REATview* assessments were subsequently compared to on-site assessments using the original REAT 2.0 instrument. This appendix describes the method and results of the feasibility study, together with implications for further research.

Methods

An online REAT 2.0 facility (*REATview*) was developed in summer 2015 using the mobile app format to record data for all fields of the original REAT 2.0 survey instrument (see http://reat.cardiff.ac.uk). *REATview* provides direct access to operational definitions and supporting photographs for each item, assisting observations which are made using *Google Street View*™ (GSV) panoramic images and associated panning tools (see Figure 1). This allows entire postcodes to be assessed remotely.

Figure 1. *REATview*



A subsample (n = 102) of the study postcodes were selected for remote assessments using *REATview*. The selected postcodes had GSV street images taken in 2011, which was the closest date available to compare with the 2012 field observations. Two auditors were trained to conduct the remote assessments and completed their assessments independently over a four week period, from the 3rd of February to the 6th March 2016. It took an average of 36 minutes (SD = 23) to complete a remote assessment of a postcode. The independent remote assessments were used to determine the IRR of *REATview*. Spearman's rank correlation (ρ) was used to determine the IRR of ordinal items and non-normally distributed REAT 2.0 components, and Pearson's correlation (r) to determine the IRR of the overall REAT 2.0 score and normally distributed REAT 2.0 components using the thresholds for interpreting strength of correlation proposed by Evans (1996). Spearman's rank correlation (ρ) and Pearson's correlation (r) were used in the same way to determine the agreement between the *REATview* and on-site assessments.

Results

Table 1 shows the IRRs for the remote assessments of REAT 2.0 components and overall score. Moderate to very strong correlations (>0.40) were found for all but the street level natural surveillance component, which had a non-significant correlation of ρ=0.15. Four out of six components showed a strong association (>0.60), with property level natural elements showing a very strong association (>0.80).

Table 1. IRRs between two independent *REATview* assessments.

		Rater 1	Rater 2		
Component	**Scale**	**M (SD)**	**M (SD)**	**IRR**	**p**
Neighbourhood condition (SL)	0-3	2.28 (0.20)	2.32 (0.29)	r = 0.45	<.001
Natural surveillance (SL)	0-1	0.45 (0.50)	0.79 (0.41)	ρ = 0.15	.134
Natural elements (SL)	0-1	0.48 (0.24)	0.50 (0.24)	ρ = 0.66	<.001
Neighbourhood condition (PL)	0-3	1.97 (0.28)	2.08 (0.29)	r = 0.79	<.001
Natural surveillance (PL)	0-1	0.97 (0.08)	0.96 (0.08)	ρ = 0.76	<.001
Natural elements (PL)	0-1	0.41 (0.18)	0.41 (0.18)	ρ = 0.94	<.001
Overall weighted REAT 2.0 score	0-10	8.59 (0.88)	9.17 (0.92)	r = 0.47	<.001

Table 2 presents the associations between the remote *REATview* assessments and an on-site assessment made in 2012. Moderate to strong associations (>0.40) were found for all components, including the overall REAT 2.0 score, with the exception of street level neighbourhood condition and property level natural surveillance components. Correlations between the remote and onsite assessments were 0.21 and 0.20 respectively for rater 1, and 0.29 and 0.28 respectively for rater 2. The highest associations were found for the

property level neighbourhood condition and natural elements components, which were both strongly correlated (>0.60).

Table 2. Associations between two *REATview* assessments and an on-site field assessments.

		Rater 1		Rater 2	
Component	**Scale**	**IRR**	**p**	**IRR**	**p**
Neighbourhood condition (SL)	0-3	*r* = 0.21	<.05	*r* = 0.29	<.001
Natural surveillance (SL)	0-1	*ρ* = 0.50	<.001	*ρ* = 0.21	<.05
Natural elements (SL)	0-1	*ρ* = 0.47	<.001	*ρ* = 0.49	<.001
Neighbourhood condition (PL)	0-3	*r* = 0.69	<.001	*r* = 0.62	<.001
Natural surveillance (PL)	0-1	*ρ* = 0.20	<.05	*ρ* = 0.28	<.001
Natural elements (PL)	0-1	*ρ* = 0.71	<.001	*ρ* = 0.69	<.001
Overall weighted REAT 2.0 score	0-10	r = 0.56	<.001	*r* = 0.43	<.001

Discussion

The results for the remote REAT 2.0 assessments using *REATview* were mixed. While the IRRs were strong for the property level assessment, they were generally weaker for the street level assessments. The correlations between the remote and on-site assessments were more varied, ranging from weak to strong. There are a number of potential explanations for the differences between remote and on site assessments and the lower IRRs at the street level. Firstly, the viewpoints afforded by *Google Street View* are different to those of site visits. That is, GSV images are typically made by a camera mounted on top of a car. This was a particular issue for assessing street level and property level natural surveillance. While natural surveillance is relatively straightforward to assess during a site visit, it requires excessive panning of GSV images around the postcode to be able to determine whether there is a clear view of the street or not, allowing for more variation in interpretation. Likewise, the height of the camera can impede the ability to determine whether windows and doors can be seen at eyelevel, again resulting in greater variation in interpretation. Furthermore, trees and large vehicles occasionally obscured views, while weather conditions and lighting at the time imagery was taken also had the potential to affect the assessments.

With the exception of natural surveillance, the associations between remote and onsite assessments, and the IRRs, were noticeably lower for street level items than for property level items. Apart from being more difficult to obtain a ‘global’ or ‘whole street’ view through GSV than during a site visit, the transient nature of some of the street level items contributing to the neighbourhood condition component, such as litter and street condition,

are also likely to affect the results of audits undertaken at different times. This echoes conclusions of previous research that found lower validity scores for more detailed observations and features that may exhibit temporal variability. Indeed, a systematic review of research comparing virtual audits with direct observation of local environments found reliability was generally weak to moderate for items related to more subjective and general aspects of streets, physical decay and disorder including litter and graffiti (Charreire et al., 2014). In addition, property level scores are based on a greater number of observations (all properties within the postcode), compared to street level scores which are based on single observations. Errors in property level assessments may therefore be averaged out, while global level assessments are based on a single observation.

Conclusion

This exploratory study found that, while it is feasible to make remote REAT 2.0 neighbourhood quality assessments, the IRRs for *REATview* were generally lower than for on-site assessments (see Poortinga et al., 2016). Furthermore, the relatively low agreement between the remote and on-site assessments for some components, particularly natural surveillance, are a cause of concern for the validity of remote assessments using *REATview*. This feasibility study also found that it takes much longer to complete a remote assessment than an on-site assessment (36 minutes as compared to 19 minutes), although this does not account for the time and costs associated with travel for on-site assessments. The difference may be due to REAT 2.0 including assessments of each individual property within the postcode, which is particularly time consuming. The property level assessments often involved zooming in and out and panning around the sides of properties to obtain a clear view.

In the absence of further development or refinement, this exploratory study shows that remote REAT 2.0 assessments should be used with caution, particularly for the assessment of ‘global’ street level characteristics. Its strengths and future research potential therefore perhaps lie in the study of property level features in geographically distant and dispersed areas, in addition to providing a useful check on field audits.