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**Responding to Nature: Natural Environments Improve Parent-Child
Communication**

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Abstract

Numerous studies have demonstrated that natural environments have a profound effect on a range of human behaviours and states, but most of those studies have examined how natural environments affect individuals rather than interactions. We examined whether natural environments affect communication between parents and their 3- to 4-year-old children. Using a novel experimental design, we show that parent-child communication is more responsive and connected in a natural environment compared to an indoor environment. This study is the first to demonstrate that human communication is influenced by natural environments. Natural settings may constitute optimal environments for communication.

Keywords: children; communication; green space; language; natural environments; outdoors; parents; social interaction

Responding to Nature: Natural Environments Improve Parent-Child Communication

Natural environments such as gardens, parks, and woodlands positively influence a range of psychological processes and states (Bowler, Buyung-Ali, Knight, & Pullin, 2010; Bratman, Hamilton, & Daily, 2012; Hartig, Mitchell, de Vries, & Frumkin, 2014; Kaplan, 1995). For example, Ryan and colleagues (2010) asked university students to evaluate their energy levels before and after taking a 15-minute walk. A researcher led individual students on a silent walk, either indoors through hallways and tunnels, or outdoors along a tree-lined path. Students who walked outdoors reported higher energy levels after the walk compared to before the walk, whereas students who walked indoors reported similar energy levels before and after the walk. Similarly, Berman, Jonides, and Kaplan (2008) compared university students' performance on an attention-demanding cognitive task, the backwards digit span, before and after a 50-minute walk in an arboretum, and one week later, along city streets (or the opposite order). Students' performance on the digit span task improved after walking in the arboretum compared to before the walk, but did not improve after walking along city streets, thus demonstrating a positive effect of natural environments on attention. In another study, adults who took a 50-minute walk through grasslands and trees reported greater decreases in anxiety, negative affect, and rumination and greater increases in positive affect compared to those who took a 50-minute walk on an urban street (Bratman, Daily, Levy, & Gross, 2015). The results of numerous correlational studies are also consistent with the hypothesis that natural environments, including both green spaces such as gardens and parks and blue spaces such as coasts and rivers, benefit human

health and behaviour (e.g., Bai, Stanis, Kaczynski, & Besenyi, 2013; Biedenweg, Scott, & Scott, 2017; Groenewegen, van den Berg, de Vries, & Verheij, 2006; White, Alcock, Wheeler, & Depledge, 2013; White, Pahl, Ashbullby, Herbert, & Depledge, 2013).

Natural environments are also associated with positive developmental outcomes for children (Chawla, 2015; Gill, 2014; Evans, 2006). In a large-scale epidemiological study, Dadvand and colleagues (2015) used satellite data to quantify 7- to 10-year-old children's exposure to green spaces at home, at school, and along the route between home and school. Exposure to green space (school greenness and a greenness index which combined greenness across residential, commuting, and school areas) was positively related to cognitive development, defined as increases in working memory and attention abilities over a 12-month period. Other observational studies have reported positive associations between natural environments and children's attention, behaviour, learning, psychological well-being, and self-regulation, as well as a reduction in the symptoms of attention deficit disorder (Coley, 2012; Faber Taylor, Kuo, & Sullivan, 2001, 2002; Flouri, Midouhas, & Joshi, 2014; Ulset, Vitaro, Brendgen, Bekkhus, & Borge, 2017; Wells, 2000; Wells & Evans, 2003). A small number of experimental studies have compared the influence of walking in a natural versus urban environment on children's attention and cognition in designs similar to those used by Berman, Jonides, and Kaplan (2008) and Bratman, Daily, Levy, and Gross (2015). Walking in natural environments has generally led to better performance amongst children, though not on all measures (Faber Taylor & Kuo, 2009; Schutte, Torquati, & Beattie, 2017). Some evidence from outdoor learning programmes also suggests that natural environments can improve attainment in

the primary school years (Quibell, Charlton, & Law, 2017). The existing evidence thus suggests several potential benefits of natural environments for child development, but is still preliminary, in particular due to limited experimental evidence demonstrating causal relations between natural environments and children's behaviour and skills.

The vast majority of studies investigating the potential benefits of natural environments have examined how environments affect individuals, rather than interactions between people. Some evidence indicates that attractive and safe natural environments can increase levels of social interaction, as well as a sense of community (Hartig, Mitchell, de Vries, & Frumkin, 2014). Coley, Kuo, and Sullivan (1997) observed more people outdoors in public spaces with trees compared to spaces without trees in two urban housing authority sites, and argued that trees and other vegetation in public spaces increase opportunities for social interactions amongst people living in urban settings. In another study, greenness of public spaces in an urban housing authority site was positively associated with neighbourhood social ties and self-reported use of public spaces, and negatively related to stress (Kuo, Sullivan, Coley, & Brunson, 1998). Neighbourhood quality, measured objectively and including features such as birdlife, lawns, and water, is positively related to people's subjective sense of community (Francis, Giles-Corti, Wood, & Knuiman, 2012). Other evidence indicates that social cohesion and stress together mediate the positive relations between natural environments and human health (de Vries, van Dillen, Groenewegen, & Spreeuwenberg, 2013; Sugiyama, Giles-Corti, & Owen, 2008). Weinstein, Balmford, DeHaan, Gladwell, Bradbury, and Amano (2015) proposed that natural environments might promote a sense of connection or

relatedness with one's surroundings, which includes not only the physical environment but also other people, and thereby enhance social interactions. They reported that in a large-scale online study with a nationally representative sample in Great Britain, self-reported contact with nature was directly and positively related to community cohesion, indicated by agreement with statements such as: "I feel connected to other people in my neighbourhood." Objective quality of nature was not directly related to community cohesion, however, raising the possibility that the association between contact with nature and community cohesion might be due to shared method variance or some other alternative explanation.

In this study we evaluated the possibility that natural environments influence the quality of human communication, specifically between parents and children. We focus on turn-taking and responsiveness as key indicators of communication quality (Hilbrink, Gattis & Levinson, 2015; McGillion et al., 2017; Snow, 1977; Song, Spier, & Tamis-LeMonda, 2014; Zimmerman et al., 2009). Communication quality is important because it impacts child development. Numerous studies over the years have identified strong links between the quality and quantity of child-directed speech and subsequent language development (e.g. Borstein, Tamis-LeMonda, & Haynes, 1999; Hart & Risley, 1995; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991; Weizman & Snow, 2001). Studies also demonstrate that children's language skills benefit from opportunities to engage with conversational partners who are responsive to their communicative bids (i.e. by following in to the child's focus of attention) and to engage in balanced conversations where both the child and adult take on comparable amounts of the conversation (e.g. Hirsh-Pasek et al., 2015; Romeo, et

al., 2018). Furthermore, there is evidence to suggest that connectedness in conversation (that is, the extent to which conversational turns that are meaningfully related to each other) is positively associated with cognitive development (e.g. Dickson, Hess, Miyake & Azuma, 1979; Dunn, Brown, Slomkowski, Tesla, & Youngblade, 1991; Ensor & Hughes, 2008; Slomkowski & Dunn, 1996).

To date there have been no systematic studies of the effects of the physical environment on human communication, including parent-child language and communication. This is surprising since, as outlined earlier, natural environments have a positive effect on a number of psychological processes and states that are central to communication and social interaction, such as attention, working memory and self-regulation. We therefore predict that natural environments will promote connected and responsive communication between parents and their children.

The Current Study

We examined the effects of physical environments on parent-child communication during exploration of a natural environment and an indoor environment. We selected a city centre park for the natural environment and the park's nature-focussed education centre for the indoor environment. Our choice to contrast thematically-linked natural and indoor environments as opposed to two different outdoor environments (e.g. natural and built) was motivated by two factors. Firstly the natural/indoor contrast has provided important insights into the effects of the environment on cognition in both adults and children, as outlined in the introduction. Secondly, there are no studies of systematically-collected spontaneous parent-child communication in natural environments and

therefore our first step is to compare parent-child communication in a natural environment with parent-child communication in an indoor environment that is both well-matched to the natural environment and broadly similar to the indoor settings in which previous research has examined parent-child communication.

Based on previous research displaying the beneficial effects of natural settings on cognition and social interaction, we reasoned that natural environments would enhance communication and connectedness. We therefore predicted that parent-child communication would be more connected and more responsive in the natural environment compared to the indoor environment. We defined connectedness as sequences of *conversational turns that are meaningfully linked*, and responsiveness as instances where speakers *follow in and respond to the content* of their social partner's utterances (Hoff-Ginsberg, 1991; Slomkowski & Dunn, 1996). To test these hypotheses, we conducted a within-subjects experiment to compare parent-child communication in our two family-friendly nature-oriented settings. Our measures include both interactional and individual language measures typical of the key measures used in studies of parent-child communication.

Method

Participants

Participants were 18 parent-child pairs (17 mother-child pairs, 1 father-child pair) (6 female children; mean age = 45 months, range = 35-56, SD = 5.72). Data from 3 additional pairs were excluded due to the child's reluctance to wear the recording equipment (n = 1) and to not adhering to the time allocated to each setting (n = 2). Table 1 displays information on the education level of the parents

and also general information on the frequency of visits to parks in general and the test site specifically.

Table 1. *Background information on the study sample*

| | Participants | |
|--|--------------|----|
| | n | % |
| Highest education level attained | | |
| Tertiary degree | 13 | 72 |
| Further education (up to 18 years) | 3 | 17 |
| High School education (up to 16 years) | 2 | 11 |
| Frequency of visits to parks | | |
| Once a month | 1 | 6 |
| Weekly | 15 | 83 |
| Daily | 2 | 11 |
| Visited Bute Park prior to study? | | |
| Yes | 13 | 72 |
| No | 5 | 28 |

We focussed on three- and four-year-old children because basic language skills are generally established by this point, while more sophisticated communicative skills and social cognition are still emerging. At three and four years, children have the linguistic tools to engage in sustained conversational episodes but are still developing the interactional skills required for meaningful and balanced interactions. Our within-subjects design ensured the power of contrasts between conditions, while at the same time allowing us to collect ecologically valid data within a short timeframe to ensure consistency across participants for environmental factors such as weather and seasonal variation. The novelty of the current study precludes power analyses since no existing studies have contrasted the effects of indoor and outdoor settings on language. However our sample size is consistent with a range of studies involving the effects of outdoors settings (e.g. Berman et al., 2008; Faber Taylor & Kuo, 2009).

All parents had a high school level education (i.e. compulsory education up until the age of 16) or above. Participants were drawn from the Cardiff area of Wales, UK and recruited through the Cardiff University Development@Cardiff database, local museums and social media. Ethical approval for all aspects of the study was provided by the University of Manchester Ethical Approval Committee. Written consent was obtained from the parents and verbal assent was obtained from the children.

Research Context

Test site. The study took place at Bute Park and Arboretum in Cardiff, Wales. Bute Park comprises an extensive area of mature parkland within Cardiff city centre. The park contains a range of trails and sculptures in addition to an arboretum and river corridor. The park also contains an indoor education centre that promotes the park's wildlife, horticulture and history. The education centre contains displays, books and child-focused craft activities. Both the education centre and the park are focused on promoting historic and wildlife interest, and are stimulating and visually pleasing environments. Therefore, the natural and indoor environments constituted distinct contexts with shared themes. For example, the education centre contained a range of displays and exhibits that reflected the flora and fauna of the park (e.g. a butterfly display and activity, pictures of local wildlife, and maps of the park and surrounding area). Importantly, both settings afforded a similar range of activities such as physical exploration, manipulation and sharing of objects, and cooperation (see Figure 1).

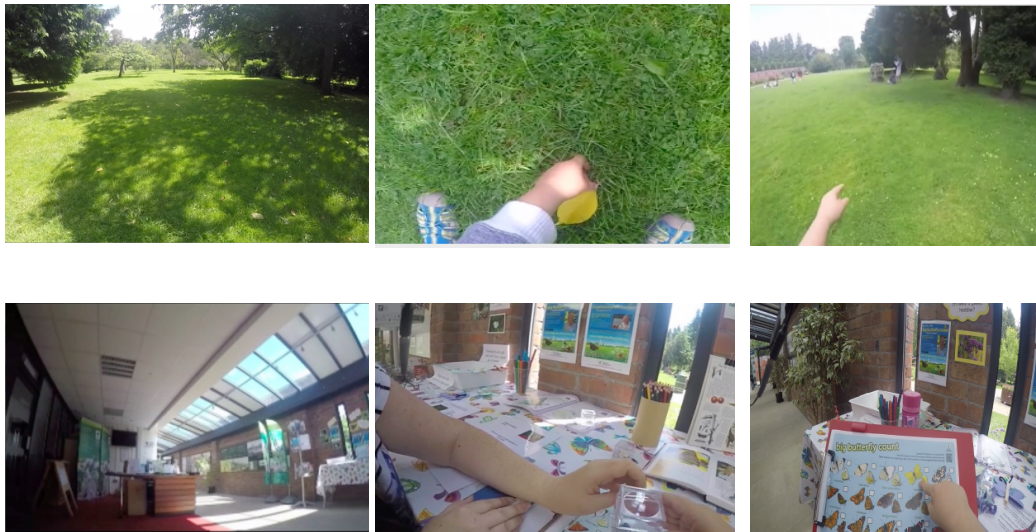


Figure 1. Still images taken from the children's head mounted cameras in the natural environment (top row) and the indoor environment (bottom row)

Design. We used a within-subjects design with environment (natural vs. indoor) as the independent variable. The order of environment was counterbalanced across the sample. The dependent measures included interactive communication measures and individual language variables. The interactive communication variables were (a) the overall number of utterances produced by the parents and children, (b) the mean length of connected communication episodes, and (c) levels of responsiveness to the co-participant. The individual language variables were (e) levels of grammatical complexity and (f) lexical diversity in the speech of the parents and children.

Procedure. The parents and children were asked to wear head-mounted video cameras (Go Pro Hero 4 Silver edition)¹ and informed that they would be recorded in two settings: in the park and in the education centre. The head-mounted cameras allowed the participants to roam freely without the intrusion of a researcher and at the same time allowed us to record both the visual and auditory components of the data, which was essential for the calculation of our fine-grained interactional measures. The participants were then given the instruction: *For the next 15 minutes, we want you to go on a treasure hunt in the (park/ centre). See what you can find.* The instruction was the same for both settings. The participants were told that the experimenter would come and find them after 15 minutes and take them to the next setting. After the recordings were conducted, the parents were asked to complete an activity questionnaire and provide general demographic information on their family (i.e. age of child and education level of the parent). Parents were provided with travel expenses and the children were provided with a small gift to thank them for their participation.

Language Analysis Coding

All recordings were transcribed in ELAN (Sloetjes & Wittenburg, 2008) by trained transcribers and checked by the first author. The measures of number of utterances, length of connected communication episodes, and proportion of responses were calculated directly from ELAN. We outline each of the dependent variables below.

¹ Participants were also equipped with pedometers but due to mechanical issues in some data collection sessions the measures were not entered into the analyses.

Number of utterances. Utterances were defined as discrete units of speech delimited by a pause of three seconds or more.

Connected communication episodes. The mean length of connected communicative episodes measure (CC) was coded manually and calculated using a procedure based on Slomkowski and Dunn (1996). While automated procedures are available for broad calculations of conversational turn length (e.g. the Mean Length of Turn function in CLAN, and general turn taking measures in LENA), there are no automated programmes that can code whether one utterance is *logically and semantically* related to the next and thereby contributing to a meaningful conversational interaction. Therefore, all CC coding was conducted 'by hand' using the following method. The start point for each connected conversation was coded as an initiation and the CC consisted of the initiation and all subsequent logically related turns. Minimally, a CC could consist of one initiation with no response; this would be scored as having a length of 1. For example, in (1) the utterances would be coded as two independent initiations each with a CC length of 1 due to the lack of a connected response from the co-participant:

1. Parent: I can see a dog over there.

Child: Can I climb that tree?

Conversely in (2) the CC score would be 5 since the caregiver's initiation '*What shall we go and look for?*' is followed by four logically-related turns. As demonstrated in (2) a turn could consist of more than one utterance (line 3).

2. Parent: What shall we go and look for?

Child: Erm, frogs.

Parent: Frogs? Where would we find frogs?

Child: In a pool.

Parent: I don't know if there is a pool.

Interrater reliabilities were conducted on 10% of the data and were good (Cohen's kappa =0.77).

Responsiveness. The responsiveness measure was calculated within the CC analysis. All responses to initiations were counted for the parents and children separately and the final score comprised the number of responses over the total number of utterances for each parent and child.

Individual language measures. For the individual language measures of grammatical complexity and lexical diversity we imported the transcripts into CLAN (MacWhinney, 2000). The MLU function was used to measure the mean length of utterance (MLU) for the parent and child speech samples. MLU is the standard measurement of grammatical complexity used in language development studies (e.g. Brown, 1973). The measure calculates the average number of morphemes in an utterance, which is then taken as a proxy of grammatical complexity. Lexical diversity was calculated using the VOCD command (Malvern, Richards, Chipere, & Purán, 2004). VOCD calculates the proportion of different words produced, taking into consideration the overall size of the speech sample.

Results

No order or gender effects were attested in the data and therefore the analyses were conducted on the sample as a whole. All dependent variables were normally distributed with the exception of parental VOCD. Consequently, the non-parametric Wilcoxon sign rank was used for parental VOCD and Paired

Table 2. Results summary

| | Indoor Environment | | Natural Environment | | <i>t</i> | <i>p</i> | 95% Conf. Interval | Hedges' <i>g</i> |
|-------------------------------------|--------------------|-----------|---------------------|-----------|----------|----------|--------------------|------------------|
| | <i>M</i> | <i>SD</i> | <i>M</i> | <i>SD</i> | | | | |
| Number of utterances | Children 129.00 | 32.63 | 150.28 | 34.70 | 2.77 | .013 | 5.02 38.87 | .63 |
| | Parents 217.11 | 38.25 | 221.56 | 55.42 | 0.49 | .63 | -14.79 23.69 | .09 |
| Length of connected episodes | 1.75 | 0.22 | 2.27 | 0.49 | 4.59 | <.001 | .28 .76 | 1.37 |
| Responsiveness | Children 51.93 | 9.95 | 66.90 | 10.35 | 5.48 | <.001 | 9.20 20.74 | 1.47 |
| | Parents 46.15 | 9.42 | 57.72 | 8.96 | 4.02 | .02 | 5.48 17.65 | 1.28 |
| MLU | Children 3.24 | 0.76 | 3.22 | 0.85 | .13 | .90 | -0.18 .21 | 0.03 |
| | Parents 5.49 | 0.63 | 5.42 | 9.10 | .34 | .74 | -0.29 .40 | 0.01 |
| VOCDM | Children 63.83 | 14.12 | 66.80 | 13.74 | .78 | .45 | -10.98 5.07 | 0.21 |
| | Parents 80.85 | 12.40 | 83.36 | 11.68 | -1.02 | .306 | | .18 |
| | <i>Md</i> | | <i>Md</i> | | <i>z</i> | <i>p</i> | | <i>r</i> |

Note. *M*(Mean), *SD*(Standard Deviation), *Md*(Median)

Sample T-tests for all other analyses. All analyses are presented in Table 2 and discussed in turn below.

Analyses of Communication and Language

Number of utterances. Our first analysis focussed on the amount of speech produced by parents and children in each setting. The children were significantly more talkative in the natural environment than the indoor environment but there was no significant difference in terms of the quantity of parent utterances.

Length of connected communication (CC) episodes. The parent-child pairs engaged in significantly longer connected communication (CC) episodes in the natural environment when compared to the indoor environment.

Levels of responsiveness. Within the connected episodes we compared the proportion of utterances produced in response to the co-participant in the two settings. A Paired-Samples T-test based on the proportional frequency of responses indicated that both the parents and the children produced a proportionally higher number of responses in the natural environment in comparison to the indoor environment.

Levels of grammatical complexity and lexical diversity. Our final analyses compared two general measures of language in the speech of the parents and children. Levels of grammatical complexity were consistent across setting for both the parents and children as were levels of lexical diversity.

Discussion

We investigated whether and how natural environments influence human communication. Our study combined robust experimental design with fine-

grained analyses of naturalistic data collected during parent and child exploration of two settings, a city park and the park's indoor education centre. The results confirmed our hypothesis that communication is more connected and responsive in natural environments. Three- and four-year-old children were significantly more talkative in the natural environment. In addition, in the natural environment parent-child conversations were longer (i.e. more connected) and levels of responsiveness were higher for both parents and children. By contrast, the individual language measures (i.e., grammatical complexity and lexical diversity) were unaffected by setting. In the following sections, we discuss the implications of our findings with regard to our two key themes: environmental influences on human behaviour, and the context-sensitive nature of parent-child interaction.

Natural Environments Benefit Social Interactions

Our findings demonstrate that natural environments influence social interactions. Natural environments support parent-child interactions by increasing responsive and connected communicative behaviour. Our findings are consistent with a growing body of literature demonstrating positive relations between natural environments and psychological processes and states within individuals (e.g. Berman et al., 2008; Dadvand et al., 2015; Faber Taylor & Kuo, 2009; Kaplan, 1995). Our findings also make a significant and original contribution to scientific understanding of the relations between natural environments and human behaviour by providing causal evidence of the influence of natural environments on social interactions between people. Natural environments thus benefit social interactions as well as individuals.

Based on previous research we can identify and evaluate a number of possible reasons for our findings. Firstly, research indicates that natural environments have a restorative effect on human attentional processes as captured in the seminal work of Kaplan and Kaplan's Attention Restoration Theory (Kaplan & Kaplan, 1989; Kaplan, 1995). To date, most studies of Attention Restoration Theory (ART) have focussed on the attentional skills within individuals (e.g. Lee, Williams, Sargent, Williams, & Johnson, 2015; Faber Taylor & Kuo, 2009). Our findings suggest that natural environments may also promote greater levels of attention *between* individuals, and thereby influence interactions between people. Future research should investigate the potential influence of natural environments on attention between individuals, including joint attention, a psychological process that lies at the heart of meaningful communication (e.g., Tomasello, 1999).

An alternative suggestion is that the natural outdoor environment resulted in lower stress, and more positive mood, and a greater sense of connection with other people. This explanation is consistent with the results of studies conducted by Ulrich and colleagues (e.g. Ulrich, Losito, Fioritot, Miles, & Zelson, 1991) and the proposal from Weinstein and colleagues (2015) that natural environments may promote a sense of connection with other people. This too would be a logical explanation, given previously reported correlations between mood state and social interaction (e.g. Clark & Watson, 1998). The relations between the three variables (i.e. stress, mood, and connectedness) could be viewed in one of two ways. One possibility is that natural outdoor environments decrease stress, which in turn leads to more positive mood, and consequently supports more connected and responsive communication. The other possibility is that natural

outdoor environments decrease stress, which in turn supports more connected and responsive communication, and that subsequently leads to more positive mood. Both are outside the scope of our current analysis, but are a promising direction for future research.

Natural Environments Benefit Parent-Child Communication

Our finding that parents and their children engaged in more connected, balanced conversations in the natural environment builds on robust evidence concerning the context-sensitive nature of parent-child interaction (e.g. Hoff-Ginsberg, 1991; Hoicka, Jutsum, & Gattis, 2008; Noble, Cameron-Faulkner, & Lieven, 2017; Sosa, 2016). Our findings also yield new insights into the importance of physical environments for communication. Language development is influenced by meaningful communicative exchanges in which both parent and child take active and responsive roles (e.g. Snow, 1977; Zimmerman et al., 2009). Importantly, the quality of parent-child communication and degree of connectedness is positively associated with children's cognitive outcomes (Dickson et al., 1979; Hart & Risley, 2003) and the development of social cognition in particular (e.g. Ensor & Hughes, 2008). In our study, the natural environment had a unique positive effect on the interactive aspects of parent-child communication. The specific effects on the interactive aspects of language use are further underlined by the stability of the individual language measures across the two settings. Future avenues of research are planned in order to ascertain exactly what aspects of the natural environment are responsible for the positive effects.

It could be argued that there are methodological factors that contribute to our findings. For example, one could argue that the parents may have felt more

self-conscious in the indoor environment and that this affected their language use, or that the parents and children simply found the natural environment more interesting than the indoor environment. Here, the comparability of the individual measures (i.e. number of utterances, and vocabulary diversity) between the two environments are helpful. The number of utterances produced by the parents did not differ significantly during interaction in the two settings, indicating that the parents were not more self-conscious in the indoor environment. Secondly, there were no differences in the range of words produced by the parents or children during exploration of the two environments, suggesting that there were similar amounts of interest and 'things to talk about' in the two environments. Importantly, both settings shared nature themes and visually-pleasing, interesting stimuli. The main difference in parent-child communication in the two environments related to the depth and involvement of the communication as opposed to the number of objects and events available for discussion.

Given the benefits of natural environments for human behaviour and learning, it is surprising that developmental psychologists have shied away from conducting studies in outdoor settings. This gap is reflective to some extent of the sampling bias in developmental psychology, which is predominated by studies conducted in western industrialised cultures where many child rearing and learning activities occur in the home and other indoor environments. By contrast, in many other cultures, children spend considerable time outside (e.g. Callaghan et al., 2011; Ochs & Schieffelin, 1984). Therefore, understanding how the physical environment affects parent-child interaction in industrialised Western cultures will not only result in a more comprehensive understanding of

parent-child interaction but also provide a more appropriate baseline for cross-cultural comparisons and generalisations across the human population.

Future Research and Applications

Our study makes an important advance towards an understanding of the influence of natural environments on human communication and social interaction. In doing so, it opens up an exciting area for future interdisciplinary research. Firstly, future work is needed in order to ascertain exactly what aspects of the environment facilitate more connected and responsive social interactions. For example, are the present findings specific to natural settings, and if so, what aspects of the natural setting are responsible for the positive effects on communication? Secondly, future work is needed to evaluate whether our findings extend to peer communication, including communication between adults as well as communication between children. If so this avenue of research could have important implications both for basic science in terms of the cognitive processes associated with language but also for mental health and well-being therapies and interventions. Finally, the interactions between stress, mood, attentional processes and language use require detailed and extended investigation. Identifying an influence of natural environments on communication is an important first step, and understanding the processes behind this relationship has the potential to provide valuable insights into human cognition and our interactions with the world around us.

Our findings offer a promising new direction for interventions that aim to support child development. Children learn language in the context of interaction and conversational patterns associated with turn-taking (Ensor & Hughes, 2008; Hilbrink, Gattis, & Levinson, 2015). Identifying situations that promote the

interactive aspects of communication is essential both for basic science and also to inform interventions for children, including those with communicative disorders and other broader risk factors as well. Future research should evaluate the potential of natural environments as everyday contexts for language interventions both delivered through parent-child interaction and also early years settings.

Natural environments may also constitute optimal settings for learning more generally. From conversations with parents, children learn about the world, including community, concepts, and formal knowledge (Crowley, Callanan, Tenenbaum, & Allen, 2001; Frazier, Gelman, & Wellman, 2009; Paradise & Rogoff, 2009). Previous research has shown that parent-child communication can support science learning, for example, by connecting formal learning with everyday experience and by increasing transfer of knowledge across contexts (Haden, 2010; Jant, Haden, Uttal, & Babcock, 2014). Future research should examine how natural environments influence learning outcomes as a function of parent-child communication.

Before closing this section we should note the limitations of our study. The sample size was relatively small. We mitigated for this by using within-subjects design but replication with a larger sample will be informative. While the effect sizes for the interactional measures were large and robust, the small effect sizes associated with the measures of MLU and VOCD mean that type II errors for the individual language measures cannot be ruled out. Secondly, our findings may have been influenced by specific characteristics of our sample. Population estimates of British participation in higher education vary, but most estimates indicate that less than 50% of adults go to university, whereas in our sample just

over 70% of parents were university-educated, indicating that our sample was somewhat more educated than the population. In addition the majority of families in our study reported visiting parks at least once a week, and we do not know whether this level of visiting parks is typical of British families with 3- and 4-year-olds. Importantly, however, we observed robust differences in parent-child communication in natural and indoor environments with a sample that includes parents who did not have university degrees and who did not visit parks with their children frequently. Future research should examine the effects of natural environments on parent-child communication for families from other cultural and socio-economic backgrounds. Finally, our analysis focussed on language interaction within each environment as a whole as opposed to breaking down the sessions into activity-specific episodes (e.g. climbing trees, sharing books). Future research with larger samples could investigate the interaction between activity, setting, and language use. On a related note, it will also be important to build on the findings of the current study with future research comparing parent-child communication in urban and natural environments.

Conclusion

Natural environments influence social interactions as well as individuals. In this study, natural environments influenced social interactions between parents and children by increasing connected, responsive communication. These contexts may improve outcomes for interventions focused on cognitive and linguistic development. The positive influence of natural environments on human communication shows that when we respond to nature, we also respond to each other.

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References

- Bai, H., Wilhelm Stanis, S. A., Kaczynski, A., T., & Besenyi, G. M. (2013). Perceptions of neighborhood park quality: Associations with physical activity and body mass index. *Annals of Behavioral Medicine, 45*, S39-S48.
- Berman, M. G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting with nature. *Psychological Science, 19*, 1207-1212.
- Biedenweg, K., Scott, R. P., & Scott, T. A. (2017). How does engaging with nature relate to life satisfaction? Demonstrating the link between environment-specific social experiences and life satisfaction. *Journal of Environmental Psychology, 50*, 112-124.
- Bowler, D. E., Buyung-Ali, L. M., Knight, T. M., & Pullin, A. S. (2010). A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health, 10*, 456.
- Bratman, G. N., Daily, G. C., Levy, B. J., & Gross, J. J. (2015). The benefits of nature experience: Improved affect and cognition. *Landscape and Urban Planning, 138*, 41-50.
- Bratman, G. N., Hamilton, J. P., & Daily, G. C. (2012). The impacts of nature experience on human cognitive function and mental health. *Annals of the New York Academy of Science, 1249*, 118-136.
- Brown, R. (1973). *A first language: the early stages*. Cambridge, MA: Harvard University Press.
- Callaghan, T., Moll, H., Rakoczy, H., Warneken, F., Liszkowski, U., Behne, T., & Tomasello, M. (2011). Early social cognition in three cultural contexts.

Monographs of the Society for Research in Child Development, 76, 1-142.

- Chawla, L. (2015). Benefits of nature contact for children. *Journal of Planning Literature, 30, 433-452.*
- Clark, L.A., & Watson, D. (1988). Mood and the mundane: Relations between daily life events and self-reported mood. *Journal of Personality and Social Psychology, 54, 296-308.*
- Coley, J. D. (2012). Where the wild things are: Informal experience and ecological reasoning. *Child Development, 83, 992-1006.*
- Coley, R. L., Kuo, F. E., & Sullivan, W. C. (1997). Where does community grow? The social context created by nature in urban public housing. *Environment and Behavior, 29, 468-494.*
- Crowley, K., Callanan, M. A., Tenenbaum, H. R., & Allen, E. (2001). Parents explain more often to boys than to girls during shared scientific thinking. *Psychological Science, 12, 258-261.*
- Dadvand, P., Nieuwenhuijsen, M., Esnaola, M., Fornes, J., Basagaña, X., Alvarez-Pedrerol, Rivas, I., Lopez-Vincente, M., Montserrat De Castro, P., Suf J., Jerrett, M., Querol, X., & Sunyer, J. (2015). Green spaces and cognitive development in primary schoolchildren. *Proceedings of the National Academy of Sciences USA, 112, 7937-7942.*
- de Vries, S., van Dillen, S. M. E., Groenewegen, P. P., & Spreeuwenberg, P. (2013). Streetscape greenery and health: Stress, social cohesion and physical activity as mediators. *Social Science & Medicine, 94, 26-33.*
- Dickson, W. P., Hess, R. D., Miyake, N. & Azuma, H. (1979). Referential communication accuracy between mother and child as a predictor of cognitive development in the United States and Japan. *Child Development, 50, 53-59.*

- Dunn, J., Brown, J., Slomkowski, C., Tesla, C., & Youngblade, L. (1991). Young children's understanding of other people's feelings and beliefs: Individual differences and their antecedents. *Child Development, 62*, 1352-1366.
- Ensor, R., & Hughes, C. (2008). Content or connectedness? Mother-child talk and early social understanding. *Child Development, 79*, 201-216.
- Evans, G. W. (2006). Child development and the physical environment. *Annual Review of Psychology, 57*, 423-451.
- Faber Taylor, A., Kuo, F. E., & Sullivan, W. (2001). Coping with ADD: The surprising connection to green play settings. *Environment and Behavior, 33*, 54-77.
- Faber Taylor, A., Kuo, F. E., & Sullivan, W. C. (2002). Views of nature and self-discipline: Evidence from inner city children. *Journal of Environmental Psychology, 22*, 49-63.
- Faber Taylor, A., & Kuo, F. E. (2009). Children with attention deficits concentrate better after walk in the park. *Journal of Attention Disorders, 12*, 402-409.
- Flouri, E., Midouhas, E., & Joshi, H. (2014). The role of urban neighbourhood green space in children's emotional and behavioural resilience. *Journal of Environmental Psychology, 40*, 179-186.
- Francis, J., Giles-Corti, B., Wood, L., & Knuiaman, M. (2012). Creating sense of community: The role of public space. *Journal of Environmental Psychology, 32*, 401-409.
- Frazier, B. N., Gelman, S. A., & Wellman, H. M. (2009). Preschoolers' search for explanatory information within adult-child conversation. *Child Development, 80*, 1592-1611.
- Gill, T. (2014). The benefits of children's engagement with nature: A systematic literature review. *Children Youth and Environments, 24*, 10-34.

- Groenewegen, P. P., van den Berg, A. E., de Vries, S., & Verheij, R. A. (2006). Vitamin G: Effects of green space on health, well-being, and social safety. *BMC Public Health, 6*, 149.
- Haden, C. A. (2010). Talking about science in museums. *Child Development Perspectives, 4*, 62-67.
- Hart, B., & Risley, T. (1995). *Meaningful differences in the everyday experience of young American children*. Baltimore, MD: P.H.Brookes.
- Hart, B., & Risley, T. (2003). The early catastrophe: The 30 million word gap by age 3. *American Educator, 27*, 4-9.
- Hartig, T., Mitchell, R., de Vries, S., & Frumkin, H. (2014). Nature and health. *Annual Review of Public Health, 35*, 207-228.
- Hilbrink, E. E., Gattis, M., & Levinson, S. C. (2015). Early developmental changes in the timing of turn-taking: A longitudinal study of mother-infant interaction. *Frontiers in Psychology, 6*, 1492.
- Hirsh-Pasek, K., Adamson, L. B., Bakeman, R., Owen, M. T., Golinkoff, R. M., Pace, A., Yust, P., & Suma, K. (2015). The contribution of early communication quality to low-income children's language success. *Psychological Science, 26*, 1071-1083.
- Hoff-Ginsberg, E. (1991). Mother-child conversations in different social classes and communicative settings. *Child Development, 62*, 782-796.
- Hoicka, E. K., Jutsum, S., & Gattis, M. (2008). Humor, abstraction, and disbelief. *Cognitive Science, 32*, 985-1002.
- Huttenlocher, J., Haight, W., Bryk, A., Seltzer, M., & Lyons, T. (1991) Early vocabulary growth: Relation to language input and gender. *Developmental Psychology 27*, 236-48.

- Jant, E. A., Haden, C. A., Uttal, D. H., & Babcock, E. (2014). Conversation and object manipulation influence children's learning in a museum. *Child Development, 85*, 2029-2045.
- Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. New York: Cambridge University Press.
- Kaplan, S. (1995). The restorative benefits of nature: Towards an integrative framework. *Journal of Environmental Psychology, 15*, 169-182.
- Kuo, F. E., Sullivan, W. C., Coley, R. L., & Brunson, L. (1998). Fertile ground for community: Inner-city neighborhood common spaces. *American Journal of Community Psychology, 26*, 823-851.
- Lee, K. E., Williams, K. J. H., Sargent, L. D., Williams, N. S. G., & Johnson, K. A. (2015). 40-second green roof views sustain attention: The role of micro-breaks in attention restoration. *Journal of Environmental Psychology, 42*, 182-189.
- MacWhinney, B. (2000). *The CHILDES project: Tools for analyzing talk. 3rd. Edition*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Malvern, D., Richards, B., Chipere, N., & Purán, P. (2004). *Lexical diversity and language development*. New York: Palgrave Macmillan.
- McGillion, M., Herbert, J. S., Pine, J., Vihman, M., dePaolis, R., Keren-Portnoy, T., & Matthews, D. (2017). What paves the way to conventional language? The predictive value of babble, pointing, and socioeconomic status. *Child Development, 88*, 156-166.
- Noble, C., Cameron-Faulkner, T., & Lieven, E. (2017). Keeping it simple: The grammatical properties of shared book reading. *Journal of Child Language, 45*, 753-766.

- Ochs, E. & Schieffelin, B. (1984) Language acquisition and socialization: Three developmental stories. In R. Shweder and R. LeVine (eds.). *Culture Theory: Mind, Self, and Emotion*. Cambridge: Cambridge University Press.
- Paradise, R. & Rogoff, B. (2009). Side by side: Learning by observing and pitching in. *Ethos*, 37, 102-138.
- Quibell T., Charlton J., & Law J. (2017). Wilderness schooling: A randomised controlled trial of the impact of an outdoor education programme on attainment outcomes in primary school pupils. *British Educational Research Journal*, 43, 527-587.
- Romeo, R. R., Leonard, J. A., Robinson, S. T., West, M. R., Mackey, A. P., Rowe, M. L., & Gabrieli, J. D. E. (2018). Beyond the 30-million-word gap: Children's conversational exposure is associated with language-related brain function. *Psychological Science*, ePub ahead of print.
- Ryan, R. M., Weinstein, N., Bernstein, J., Brown, K. W., Mistretta, L., and Gagne, M. (2010). Vitalizing effects of being outdoors and in nature. *Journal of Environmental Psychology*, 30, 159-168.
- Schutte, A. R., Torquati, J. C., & Beattie, H. L. (2017). Impact of urban nature on executive functioning in early and middle childhood. *Environment and Behavior*, 49, 3-30.
- Sloetjes, H., & Wittenburg, P. (2008). Annotation by category – ELAN and ISO DCR. In: *Proceedings of the 6th International Conference on Language Resources and Evaluation (LREC 2008)*. <http://tla.mpi.nl/tools/tla-tools/elan/> Max Planck Institute for Psycholinguistics, The Language Archive, Nijmegen, The Netherlands.

- Slomkowski, C., & Dunn, J. (1996). Young children's understanding of other people's beliefs and feelings and their connected communication with friends. *Developmental Psychology, 32*, 442-447.
- Snow, C.E. (1977) The development of conversation between mothers and babies. *Journal of Child Language, 4*, 1-22.
- Song, L., Spier, E. T., & Tamis-Lemonda, C. S. (2014). Reciprocal influences between maternal language and children's language and cognitive development in low-income families. *Journal of Child Language, 41*, 305-326.
- Sosa, A. V. (2016). Association of the type of toy used during play with the quantity and quality of parent–infant communication. *JAMA Pediatrics, 170*, 132–137.
- Sugiyama, T., Leslie, E., Giles-Corti, B., & Owen, N. (2008). Associations of neighbourhood greenness with physical and mental health: Do walking, social coherence and local social interaction explain the relationships? *Journal of Epidemiology & Community Health, 62*, e9-e9.
- Tomasello, M. (1999). *The Cultural Origins of Human Cognition.*: Harvard University Press.
- Ulset, V., Vitaro, F., Brendgen, M., Bekkhus, M., & Borge, A. I. H. (2017). Time spent outdoors during preschool: Links with children's cognitive and behavioral development. *Journal of Environmental Psychology, 52*, 69-80.
- Ulrich, R., Losito, B., Fioritot, E., Miles, M., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology, 11*, 201-230.
- Wells, N. M. (2000). At home with nature: Effects of “greenness” on children’s cognitive functioning. *Environment and Behavior, 32*, 775-795.
- Wells, N. M., & Evans, G. W. (2003). Nearby nature: A buffer of life stress among rural

children. *Environment and Behavior*, *35*, 311-330.

Weinstein, N., Balmford, A., DeHaan, C. R., Gladwell, V., Bradbury, R. B., and Amano, T.

(2015). Seeing community for the trees: The links among contact with natural environments, community cohesion, and crime. *Bioscience*, *65*, 1141-1153.

Weizman, Z., & Snow, C. (2001). Lexical input as related to children's vocabulary

acquisition: Effects of sophisticated exposure and support for meaning.

Developmental Psychobiology, *37*, 265-279.

White, M. P., Alcock, I., Wheeler, B. W., & Depledge, M. H. (2013). Would you be

happier living in a greener urban area? A fixed-effects analysis of panel data.

Psychological Science, *24*, 920-928.

White, M. P., Pahl, S., Ashbullby, K., Herbert, S., & Depledge, M. H. (2013). Feelings of

restoration from recent nature visits. *Journal of Environmental Psychology*,

35, 40-51.

Zimmerman, F., Gilkerson, J., Richards, J., Christakis, D., Xu, D., Gray, S., & Yapanel, U.

(2009). Teaching by listening: The importance of adult-child conversations to

language development. *Pediatrics*, *124*, 342-349.