Can sonic feedback from human-plant interaction increase connectedness to plants?

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***Abstract* —** In an age of ongoing human technological progress and urban growth, one must wonder – what implications does this have on our ecological identities. The field of ecopyschology has, for years now, investigated the existing levels of nature connectedness in humans. However, most studies are based on self-report, are placed outside any particular environmental context and lack ways of affecting such identities.

This study provides a specific context to investigating nature relatedness – the context of human-plant interaction, or horticulture, and further analyses whether sonic feedback from such interaction can affect subjects' various feelings of connectedness to plants. The design, prototype and experiment were tested for three days in the *Hortus Botanicus*, Leiden with an overall sample group of 30 subjects.

***Index Terms* —** nature relatedness, sonic feedback, effects, human plant interaction, horticulture, ecopsychology

INTRODUCTION

As humanity progresses in the new century of increasing information and technologies, we also start to realize the influence such progress has on our surrounding environment. We know we have the means and resources, but lack the social and psychological strength to use them in resolving the current damaging practices that define our times. For some, this is due to a growing gap between our environmental and urban identities, with the latter growing largely on the expense of our connection to nature [1].

In other words, our behavior in environmental destruction, pollution and apathy towards the extinction of species, could be a result of the lack of connectedness of our 'self' to the world of nature. After all, if one feels connected to nature, its destruction would, psychologically, mean the destruction of a part of one's 'self' [2]. Examples of this can be found in practices such as vegetarianism, biking and the struggles for animal rights. One species, however, have often been left out of the human-nature debate – i.e. plants. This is not to say that they have been left out of extinction lists or that urban plantations have not been around. It is more to do with the increasing lack of interaction between humans and plants, both in restorative activities and food production, and the consequences those can have for humans and their overall connectedness to nature. Something to which technology can contribute by way of enhancement, or re-establishment, of sensory and interaction experiences.

This paper will touch upon the idea of human-plant interaction by incorporating existing artistic, scientific and technological advances in an attempt to increase such interaction through sonic feedback. The question that mostly concerns us, however, is whether such feedback can also increase feelings of connectedness towards plants? An experimental design was constructed, in order to evaluate this question. In the following section, we will briefly explain relatedness and the other concepts that are of importance to this study. In section 3, we will introduce the 'device' design and the experiment. At the end (sections 4 and 5), we will contemplate around the results, their meaning and what can be done to improve the study.

BACKGROUND

2.1 Human Connectedness With Nature: the Science Of Ecopsychology.

Ecopsychology is the *de facto* science that studies the relationship between humans and nature in psychological, but also ecological terms. One of the fundamental statements that gave the foundations of ecopsychology, is the one made by Edward Wilson. He stated that, since humans began living in cities in a later stage of their existence, they are evolutionary drawn to affiliate with the natural world and the life forms in it. In fact, we are still related to nature in some way or another and have a specific ecological identity– e.g. affection with baby mammals and similar traits [3]. Even physically, we also benefit from connectedness, with existing theories of nature restorativeness such as 'attention restoration theory', or other therapeutic effects nature has. Kaplan et al., found that nature

engages people with a more indirect attention capacity. What this means, is that it gets a person out of his/her daily routine while encouraging a sustained exploration and a fascination, or effortless attention, during the person's visit [4]. This largely lowers stress and other psychological and physiological problems.

Nevertheless, increasing time spent indoors and in urban areas certainly has effects on the above mentioned feelings. As a consequence, many researchers have investigated the existing connections between one's 'self' and nature [5, 6 and 7], in order to find the current state of human-nature connectedness. One example is the *nature relatedness scale* (NR), developed to explore affective, cognitive and physical relationships that people have with nature and the environment, by way of a self-report scale [8].

The positive side of this scale is that it researches individual affections together with physical experience of nature. In their research, Nisbet et al. found support towards a positive correlation between scoring high on the scale, time spent outdoors and environmental behaviour on a personal level [8]. The three aspects they used to explain relatedness with nature were – NR-Self, NR-Perspective and NR-Experience. NR-Self related to the interpersonal relations or the way one identifies one's self with nature. H. Friedman explained this as the way individuals construct their self-concept by identifying with concepts in their surrounding [9]. In a famous experiment, Schultz measured this aspect by a single-item scale (Inclusion of Nature in Self [10]). NR-Perspective investigates the ability of individuals to take the perspective of the natural world, similarly to our tendency of taking perspective with other people [11]. Finally, NR-Experience measured one's actual experience in nature, since this matters equally in the overall conclusions of individual connections to nature.

In summary, a number of research studies has confirmed that investigating one's relations with nature is important in determining his/her ecological identity. Such identity is important, not only for determining environmental behaviour, but also for its improvement in the future. There is a lack, however, of research into connectedness to specific species, or into relations measured in a particular context/surrounding. Also, a lack of investigations based on more objective, or tangible, aspects of relatedness, such as certain stimuli that are present in nature and can affect human relations with it.

2.2 Human-Plant Interaction: The Science Of Horticulture.

What is meant above by 'specific species', is the investigation into relations in particular environments (surroundings) or with particular species or family of species. In this article, we investigate the relations of humans and plants through the process of interaction. The field where this happens is called *horticulture* – the science and technology of plant cultivation for human benefits (restorative, i.e. gardening) or for any other use (food, medicines, etc.). The practicing of it, places horticulture somewhere in between nature and culture [12], thus making it a better practical scene to establish connections with nature. The fields of community gardening and horticultural therapies are a sign of this. As Edwin Dobb best put it – "Gardeners do not visit nature, worship, then withdraw quietly; they occupy it; get their hands dirty. Moreover gardeners embrace their dilemma: they accept that they cannot get what they want without also doing what the garden wants. No matter how hard they try, they cannot force cherry trees to bear pumpkins [...]" [13].

Hence, the interaction between humans and plants is a direct physical, emotional and cognitive experience that can and should have consequences on the overall connectedness of humans with their environment. Furthermore, it bridges the gap between people and the world of plants, by confronting the former directly with the latter, as mentioned above. In other words, more time spent with plants, should mean better ability to feel connected with them. And although many horticultural programs do exist, they are mainly centered around therapeutic and restorative purposes, rather than an increase of affections between humans and plants.

2.3 Nature sound effects on humans: The sonic garden

The conclusion that one can draw from the studies of ecopsychology and horticulture, is that measuring nature relatedness needs to happen in a more in-depth scenario. This can, for example, happen by confronting people with some sort of tangible or sensory experience within a specific context of nature – in this case the interaction with plants. However, in order to do that – one must find such tangible/ sensory, and in the same time implicit, way of affecting the interaction.

Several studies around effects of restorativeness and human nature connectedness, have found that the ambiance one can find in nature is a particular contributor towards the above effects [14, 15]. A particular study is one by Alvarsson et al., whereby they found that physiological recovery (stress and sympathetic arousal) is positively affected by sounds of nature [16]. Another similar study found that university students in urban areas tend to connect nature soundscapes more with feelings of nostalgia, as opposed to students in rural area [17].

Thus, one can conclude that natural sounds represent one such sensory aspect of relatedness towards nature. Such finding largely contributes to our final hypothesis that connections to and interaction with certain species (i.e. plants) can be enhanced by way of a tangible or sensory experience (i.e. a sonic garden). In the following experiment, the method to investigate the above hypothesis is designed and two more hypothesis are stated, in order to strengthen the arguments presented so far.

EXPERIMENT

In the study, participants of two groups were tested – one group would do the tasks and have sonic feedback from the interaction, while another would not – i.e. it would be the control group.

The aim of this study was two-fold – on the one hand, the study investigated the prior nature connectedness of subjects

Figure 1. *Ornithogalum Thyrsoides*

and their ability to engage in different tasks on a single plant (*Ornithogalum thyrsoides* or Star of Bethlehem (Figure 1)).

On the other hand the study aimed to, implicitly, measure any particular improvements in the relations to the plant and plants as a whole via the usage of sonic feedback during the interaction. This was done using tasks that aim at challenging the main relations tested in the self-report stage and comparing the results of the two groups that appear in the post-interaction phase to assess any particularities between the with/without sonic feedback experiments.

Given the presumptions we analyzed earlier, there are three main points that should be able to appear after the experimental stage:

- In the context of this experiment, subjects that appeared to be highly connected in an NR study, should be scoring high also on the post-questionnaire measurements;

- sound can increase interaction (through simple fascination) and, thus, leads to increase of bonding, as mentioned in section 2.2. Here, measured are differences between the test and control groups;

- natural sonic feedback coming out of human-plant interaction can increase feelings of empathy, identification of self and increased ability to take perspective with the plant-world. Such results should also appear after correcting for existing bias in both groups;

All are aspects of being related and interconnected with plants. Hence, if the latter two presumptions appear true, one is able to discuss that *sonic feedback from human-plant interaction is able to increase connectedness to plants.*

3.1 Method

The device used in this study was created in order to provide the sonic feedback from actual interaction (e.g. touch). We took in mind the background research and pilot tests, whereby tasks were created and adjusted to foster interaction and better measure a subject's levels of empathy and affections towards plants and, in this case, the plant used.

A) *Sound and sensor design*

The sound design was based, most of all, on the ideas that nature soundscapes induce fascination with nature and feelings of lower arousal, or relaxation [16]. For that reason, carefully filtered noise that reminds of rainfall drops with randomized intensity and pitch were designed in the open-source software *PureData*[18]. Low-frequency modulated envelopes are ramped every 5 seconds to set the rate at which each droplet is generated. Two different envelopes are assigned depending on data coming from the sensors – one leads to a less saturated droplet generation, while the other leads to a more saturated one, e.g. resembling a small waterfall [18].

This links to the second reasoning behind the final sound patch – the acousmatic nature of environmental soundscapes. By 'acousmatic' one means the 'unknown source of most sounds observed while being in nature' [19]. 'Environmental acousmatics', as Lopez called them, can also be connected to the idea of 'reduced listening' coined by *musique concrète* artist Pierre Schaeffer [20]. For this reason, in the design, an array of 10 notes is sent in random order to a bandpass filter every 5 seconds to set the final sound of each of the 'objects/droplets' in the final soundscape. Hence, every 5 seconds, up to 10 droplets, each with random tone and one of the two specific envelope saturations, can be generated.

As to the sensors that detect the touching of the plant's leaves - the influence here was from the many experiments done with galvanic sensors on plants, also known as the Backster effect [21]. In Cleve Backster's experiments, he attached his polygraph electrodes to the plant's leaves and observed changes of conductivity in the leaves, assuming a 'conscious' state of arousal if the leaves were filled with more water, hence were conducting electricity easily. Being heavily discredited as pseudoscience, the design is currently used by many artists as a way of 'giving a voice' to plants, rather than for any objective measures of plant sentience. In this experiment, it is used just for obtaining data from interaction on which the sonic feedback can be mapped and no “plant state” is measured or used. In other words, we are interested in the experience of humans and not in detecting any accurate plant feedback.

The final prototype was done by using a Wheatstone bridge device (based on Vadim Gerasimov's GSR design in *MIT* [22]) and two copper taped electrodes. It detected two main events – touching of leaves and spraying water on leaves, which later became basis for the creation of interaction tasks. When touching a leaf, one activates the less saturated envelopes mentioned above. However, increase in data will increase the amount of droplets (up to 10 droplets). If the data, however, begins to peak – in this case, if water gets on the electrodes, then all droplets are generated with more saturated envelopes, in order to get a different feedback, without losing the effect of random generation.

This randomness, based on the above contexts, creates a sort of perceptual detachment from the direct visual interaction

between the human and the plant, without losing the feeling of actual feedback from touching and spraying water on plant [23].

B) *Subjects and location*

Thirty individuals (13 male and 17 female) were randomly invited to participate. The age ranges were diverse – with most participants being in the range of 21-29 and the rest spreading equally throughout 30-49 and 50 and above. Hence, the overall sample group gave a sufficient variance in age and sex. As to nationality, most subjects were Dutch, with a few American, German and one Slovene.

They were approached in a botanical garden in Leiden – *Hortus Botanicus*, during three full working days between 20th-23rd of July, 2013. The context itself can lead to assumptions that the sample group will be more connected to nature, thus creating a bias. However, as mentioned above, what mainly is of interest in the study is the affect of sonic feedback on connectedness and not the solely connectedness by itself. Nevertheless, pre-interaction tests are made to assess any biases in the results (see point D) and to support the here-stated presumption.

C) *Procedure*

Potential subjects were approached and, if agreeing to participate, were given a verbal explanation of the research (saying it was aimed at 'investigating human-plant interaction') and given a seat in front of the setup and questionnaire papers.

There, they filled in short demographics information, a scale to measure their relationship with nature, implemented several tasks on the plant and, at the end, filled a single graphical question. The latter three are explained in detail below.

D) *Nature relatedness scale*

As discussed, humans feel inclined to affiliate with other living things [3]. Such feelings can include how one is able to identify with nature, take perspective with it and/ or analyse the emotional empathy that one feels for nature. But to be able to look into those aspects of relatedness, one must also get a basic understanding of each subject's physical experience with nature, or their existing environmental identities.

The main scale chosen in this study is the Nature relatedness scale, developed by Elizabeth Nisbet, John Zelenski and Steven Murphy [8]. It is a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree" and its main advantage is its investigation of three aspects of relatedness, as explained in section 2. Scoring high on the scale would mean better connection on each of the aspects, or with nature as a whole. In this experiment the NR scale was suited towards getting an understanding of the overall sample group and the pre-existing relations that exist towards nature.

The final scale consisted of 11 questions (Appendix A) and was designed by choosing the less explicit/ direct questions, for reasons of wanting to preserve subjects from easy judgements before proceeding to the tasks. In addition, it further distinguished between ability to have emotional empathy with nature and the ability to identify certain interpersonal relations with it. Included were 3 questions analysing ability to *identify with nature (IR)*, 2 questions identifying feelings of *emotional empathy (EE)*, 2 questions on *taking perspective with the natural world (TP)* and 4 questions looking at overall *physical experience within it (PE)*.

Finally, each subject is asked on the average time spent in nature, while abstaining to clearly define "nature" and leaving the choice with the subjects.

E) *Interaction tasks*

In the second stage, subjects would start interacting with the plant by being asked to touch the plant and do a few gardening tasks (5 tasks overall, Appendix B). In those tasks, subjects from the two groups would differ in having and not having sonic feedback from the interaction.

As explained earlier, horticulture is the field where humans and plants meet extensively and develop relations**.** By asking people to engage in close contact with the plant, as in the first two tasks, they become actively and tangibly involved with it. While, on the other side, the interaction gives way for the emergence of the acousmatic sound. The final three tasks are typical gardening tasks, with the last one, a more "cognitive" task, whereby decision of 'cutting a damaged leaf' is left with the subject. Such tasks are, as Pollan mentions, a better way (then simple observation) for people to understand their present position in "the grand scheme of things", i.e the world of plants and nature [24]. Hence, such interaction tasks give way to the specific context of human-plant interaction, whereby connectedness can be further researched.

As mentioned before, subjects who had sonic feedback, were asked to wear headphones. The reasons were in the immersion effect of headphones, as opposed to stereo speakers which were used in the pilot testings. Finally, all tasks left the subjects to interact with the plant, for as long as they wanted to, in order to assess any temporal differences in the two groups' bonding with the plant.

F) *Measurement/ challenging tasks*

After going through the interaction-aimed tasks, subjects are asked to 'take headphones off' and continue doing the rest of the tasks. This was partly due to the desire to measure the two groups without any differences whatsoever.

Firstly, subjects are introduced to the plant's origin and its habitat information. After that they are asked to do 4 tasks on the plant **(**Appendix C). The tasks themselves present an implicit challenge at each of the aspects of relatedness (without physical experience (PE)), although some are more directly connected then others.

For example, the first task they need to do is to 'set a price' for which they think the plant should be sold, as a measurement task related to taking perspective (*TP*). In the experiment, they can stay "Neutral" or set a price. An anthropocentric

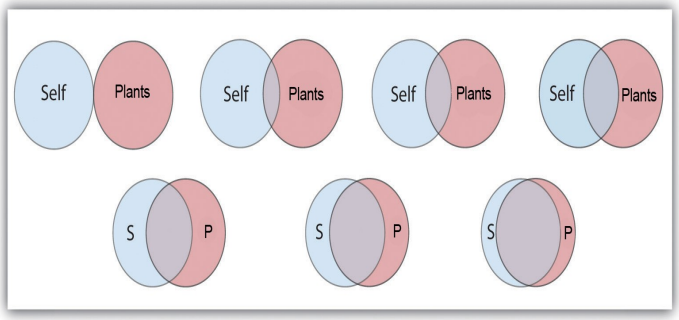

Figure 2*: Inclusion of Plants in Self scale*

(predominantly human) attitude towards the plant would mean setting a price. In other words, commodity (expressed by the universal commodity of money) labeling is a behavior that lacks the ability to take perspective from a plant point of view [25]. Choosing "Neutral" would mean refusing to take the plant as a commodity and taking a more plant-oriented perspective.

Further to this, subjects are asked to read a poem by Khalil Gibran to the plant. The poem is written in second person, encouraging the subjects to personally identify with the plant ('identifying with nature' *IR*). Reading poetry being a process of interpersonal exchange of emotions – i.e. the reader engages on an exchange of symbols/ language [26], developing interpersonal relations. Furthermore, transforming poetry into something more than just a verbal context, gives it another level of interpersonal relations [27].

Here, freely reading 'out loud' the poem, as opposed to simply reading it silently, would mean stronger ability to identify a "present listener" [27] – i.e. the plant, even though one might know that plants do not have hearing capacity. A more subjective and experimental task, it should nevertheless measure more interpersonal relations of the subject with the plant.

Finally, two tasks challenge the person's empathy towards the plant ('emotional empathy', *EE*). In particular, emotional concern is what is evoked, by challenging the subjects to engage in a potential damage to the plant, while being able to chose less harmful methods. Emotional empathy is concern for other's emotional state that comes more automatic than other, more cognitive, processes [28]. The two implicit tasks – put dirty soil and pierce through the plant's leaf with a push pin, while being able to get rid of the cigarettes in the soil and chose less pervasive methods of attaching one's name to the leaf (elastic or blue-tag), challenge the subjects' level of emotional concern for the plant. Recorded
are such levels of concern – i.e. the choices made reflect those levels. Final conclusions are done on terms of differences in levels of empathy between the two groups.

G) *Inclusion of Self in Plants scale*

All subjects were also asked to fill in the one-item scale, created by Schultz [10]. Participants are asked to rate their feelings of connectedness with plants, by choosing between 7 images (Figure 2) of two overlapping circles (starting from 1= least overlapping, until 7= almost part of the same circle). This question was the last one to fill in the experiment, attempting to record any differences in the self-expansion or inclusion of plants inwards the self. Similar to the poem task, it records a subject's ability to have any type of interpersonal links with plants.

H) *Final interviews*

At the end of the experiment, each subject was asked a few open ended questions, such as "What did you think of what you just went through?", "How did the tasks feel", "How about the sound?", "How did you set the price?" and "Add any comments/ observations you had during the experiment?".

TABLE 1
Results from each aspect of Nature Relatedness (NR) scale, showing average (AVG) and standard deviation (SD)

AVG ± SD	Interpersonal relations IR	Emotional empathy EE	Taking perspective TP	Physical experience PE
Sample group (n=30)	3.5 ± 1.2	3.1 ± 1.1	3.6 ± 0.8	4.2* ± 0.8*

* In question 9 SD and AVG were calculated with n=7, instead of n=15, and normal distribution was assumed

TABLE 1a
Results from each aspect of Nature Relatedness (NR) scale, showing average (AVG) and standard deviation (SD)

Group	IR	EE	TP	PE
Control AVG ± SD	3.4 ± 1.2	2.8 ± 1.1	3.2 ± 0.9	3.9 ± 0.8
Test AVG ± SD	3.7 ± 1.2	3.5 ± 1.1	4 ± 0.8	4.5* ± 0.8*

*In question 9 SD and AVG were calculated with n=7, instead of n=15, and normal distribution was assumed

TABLE 2
Results from Interaction tasks, showing average (AVG) and standard deviation (SD)

Group	Time (Min,Sec)
Control AVG ± SD	2.2 ± 0.9
Test AVG ± SD	3.4 ± 1.2

TABLE 3
Results from Measurement Tasks (MR) in percentage of subjects from each group's population with any of the 3 aspects

Group / Task	IR Poem	EE Damage tasks	TP Price
Control	40%	52.5%	0%
Test	55%	54.5%	13%

TABLE 3a
Results from Nature Relatedness (NR) scale compared with results from Measurement Tasks (MT) of both groups

Group / Stage	IR - NR	EE - NR	TP - NR
Control	3.4 ± 1.2	2.8 ± 1.1	3.2 ± 0.9
Test	3.7 ± 1.2	3.5 ± 1.1	4 ± 0.8
MT	**Poem**	**Damage tasks**	**Price**
Control	40%	52.5%	0%
Test	55%	54.5%	13%

TABLE 3b
Results from Measurement Tasks of the high-scoring and low scoring connectedness control and test groups

Group	IR	EE	TP
Control high	70%	50% + 50% = 50%	0%
Test high	70%	60% + 50% = 55%	22%
Control low	37%	61% + 38% = 49%	0%
Test low	44%	60% + 40% = 50%	0%

TABLE 4
Results from Inclusion of plants in self scale (IPS), showing average and standard deviation of the two full groups and average of the four high-low groups

Group	IPS
Control full AVG ± SD	3.1 ± 1.6
Test full AVG ± SD	4.2 ± 1.3
Control low AVG ± SD	2.9 ± 0.8
Test low AVG ± SD	4.1 ± 0.7
Control high AVG ± SD	3.5 ± 0.7
Test high AVG ± SD	4.1 ± 1.1

3.2 Results

In the following two sections, we will present the results of the experiment and discuss them in more detail, relating them to constructs we discussed earlier.

A) *NR scale and environmental relations*

Responses in the questionnaire were averaged and subject to standard deviation. Answers were rated 1-5 starting from the least related to most related. Final scores were calculated on each aspect of nature relatedness (see table 1) and also on each group separately (see table 1a). According to results, each of the two groups was further separated in two groups – one including the subjects that scored higher than the median of the overall sample group and one with the subjects that scored lower (table 3b). This was done to better evaluate the measurement tasks, correcting for any bias that comes out because of the level of connectedness of subjects. In other words, testing whether highly connected subjects (test or control) will have the tendency to score higher on the measurement tasks. Results of that will be discussed further in section 3.3.

B) *Increase of interaction through sound*

As seen in Table 2, the presumption that interaction can be increased through sonic feedback, did show positive results with the test group. Standard deviation on the time each group spend were calculated and also showed stability.

The open questions quality test showed that subjects were interested in the "novel perspective" they were placed by doing the interaction tasks. Most subjects expressed satisfaction from the interaction and were happy while doing the tasks.

C) *Sonic feedback increases relatedness towards plants*

As to the effects of such feedback on subjects' relatedness towards plants, results in the tables (3, 3a/b and 4) appeared, in some way or another, in relation to our hypotheses**.** They were calculated in percentage of subjects from each of the groups, that showed relatedness to each of the three aspects. In other words, only those that took choices that correlate positively to the aspects of relatedness (e.g. read poem aloud) were included in the percentage. Since a few people appeared concerned for the plant while, in the same time, doing damage on the plant in the last two tasks, they were rated with half a point on EE in order to keep objectivity in the levels of relatedness. Furthermore, another person was also rated half point on IR since the poem was read aloud only half way.

As mentioned above, the two groups were further split into those with high scores and those with low scores on the NR scale. The results (table 3a) were calculated again in percentage of each of the four groups and appear to have close relation to the preexisting connectedness of subjects.

As to the IPS scale (table 4), in terms of standard deviation, there were some variances in the distribution in control and test. None striking enough, however. Average and standard deviations were also calculated for each of the four groups and showed a normal distribution.

Finally, the qualitative assessment results gave no support of the hypothesis that sound is explicitly increasing any feelings of connectedness to plants (with the exception of two subjects). As mentioned above, this can be due to the lack of contextual connection of the sound itself.

3.3 Discussion

A) *NR scale and sample group' environmental relations*

All in all, the overall sample group seemed to identify with nature on a level above the average, having some sort of relatedness with it. As to between-group bias, the test group showed better affinity in taking perspective with the natural

world and bigger emotional concern for it. This bias was not expected and is undesired since both groups were randomly selected. However, it can be later corrected through looking at the newly formed four groups (table 3b) of high and low connected subjects. The highly connected (both in control and test) subjects tend to score higher on the measurement tasks than the low ones. Thus, confirming our first presumption.

All this meant that, having in mind the context where the experiment was held, the sample group is not completely random and already has established relations with nature. Nevertheless, differences in the low test and control and high test and control were also present which we will discuss further below.

B) *Increase of interaction through sound*

As stated above, the test group took, on average, a minute more to interact with the plant. Such results can be connected with, either, simple fascination or a novelty effect, which states that introduction of new technology leads to improvement of interest and performance [29]. The latter can be subject to change when including test-retest methods in a future experiment.

Nevertheless, answers from the quality assessment give some back-up that providing sonic feedback can increase interaction, even implicitly. Most test subjects initially reacted neutral to sonic feedback, either thinking the sound was appearing 'too random' or even lacking a notice for the sound whatsoever. The latter could be explained with the 'lack of visual context' to the feedback that we discussed in the "Method" section.

Thus, one can conclude that sonic feedback in this experimental design did increase, more implicitly, the time people spent interacting with the plant, hence also the time spent in a horticultural context.

C) *Sonic feedback increases relatedness towards plants*

The data show differences in test and control groups in terms of high-low connected subjects' performance on measurement tasks. Nevertheless, differences may not be big enough to make a firm conclusion regarding our third hypothesis - that sonic feedback did affect any of the aspects in the subjects.

For example, both groups showed similar levels of emotional empathy with the plant. Most subjects in both groups were more or less concerned in damaging the plant and 'felt bad' for it (table 3). If one is to look at the differences between the two groups in the questionnaire (table 3a) and the four high-low groups (table 3b), data is also at similar differences. Hence, here, the test group appeared to have no distinguishable effect from sound.

Concerning refusing to put a price on the plant, or being able to take less of an anthropocentric perspective, two people from the test group did remain "neutral", while the whole control group put some price. Most subjects set different prices and, when asked in the qualitative, claimed that they were thinking of market prices most of all. One person connected the price value with the fact that she already bonded with the plant. However, the only two people refusing to set a price are insufficient to support any increasing in this aspect. The fact that they both appear in the highly connected test group also contributes to this issue. Thus, more research around this aspect is needed.

As to the ability to identify with the plant and read the poem, or to have some sort of interpersonal skills, the difference also appears larger in test subjects. Interestingly, the difference here is more in the low-connected test and control subjects. Although the poem task can appear subjective or too experimental, it showed to be less of an issue with nearly half of the whole sample group being able to treat the plant as a "listener", all of which (with exception of the subject mentioned in the previous section) actually turning to the plant when reading. In other words, although the difference here can appear insignificant to support an effect, the task itself showed interesting human-plant relations. This is also supported by the fact that both groups had no sound while during the measurement tasks, hence sound from the interaction stage did have some difference on the test subjects, especially the low-connected ones.

Differences in interpersonal relations are also present in the self-report graphical question at the end of the experiment, whereby they can be labeled as 'positive'. Here, test subjects showcased higher levels of inclusion of plants in 'self'. Such differences are even bigger, interestingly, in-between the low-scoring test and control subjects. Furthermore, positive results include a smaller difference that test subjects have, thus including, more or less on the same level, plants in their construct of 'self', regardless of their preexisting differences. Hence, when combined with the poem task results, it seems that the most noticeable difference is in the way test subjects treated the plant as part of their construct of 'self', or the way they are able to personally identify with the world of plants. With attention being drawn towards the low-connected test subjects, whereby such relations towards the plant were maybe unexpected.

In summary, a slight increase in interpersonal relations and ability to take perspective with the plant did appear, supporting the assumption that acousmatic sound from the interaction can affect changes in connectedness of test subjects. More research around the aspects of connectedness and more experiments with this similar design, are needed in order to support the above seen results.

GENERAL DISCUSSION AND FUTURE RESEARCH

All in all, this experiment turned out interesting in the way it confronted people with a slightly more specific context – interaction with a single plant, while also trying to underline a sensory aspect of that interaction. It also showed that it is possible to investigate connectedness not just through self-report. Although it relied on several experimental-in-nature objective measurements, results did confirm that subjects are affected, in one way or another, simply by interaction, but also by the sensory feedback (sound) from this interaction.

There are several aspects that can be improved, however. Starting with the amount of subjects to be tested and going to

the amount of plants that they can interact with. Having only thirty people does have an influence on any firm conclusions that one can draw. For example, differences in two people are insufficient to be able to affirm any positive or negative conclusions. Also, a more long term study, including test-retest methods, will reveal any spontaneous or other time-affected answers.

The context itself, as seen from this study, is important – a botanical garden does shape the nature of the experiment. However, this is not necessarily a negative point – one can think of placing the experimental design more inside the actual garden, instead on a table in the entrance. More plants, mean more flexibility in the design of objective measures, but also more flexibility around the focus on sensory aspects of the garden and the focus on ways of interacting. Other ideas include doing controlled experiments around interaction with a fake plant – i.e. looking for differences in researching connectedness between actual lifeforms and simply artificial objects. Thus, in the future, a larger design (towards an actual sonic garden), focusing more on tightly connecting the sensory experience with the particular context of human-plant interaction, can give even more interesting results and implications on investigating nature and plant relatedness and their potential improvement. Such design should also allow for more implicit measurements without the presence of an 'experimenter', which should give more ground for 'truthful' results.

Conclusion

To conclude, this paper attempted at analyzing the current status of the ecopsychological debate around nature relatedness and its implications on individual ecological identity. It also suggested a different approach to investigating such relatedness – by combining aesthetic and scientific methods to create a context where it looked at the sensory experience of nature and whether it is able to affect the individual status of nature connectedness. Although results appeared inconsistent or insufficient to draw a firm conclusion, one can conclude that sonic feedback from human-plant interaction might just be able to affect, even implicitly, the way humans perceive species of nature and their ability to feel more interconnected with them. However, more research around sensory experience of nature and different contexts of interaction are what is needed in the future.

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Appendix a – NR survey

Inclusion of nature in 'self'

1. The thought of being deep in the woods, away from civilization, is frightening
2. My personal welfare is independent of the welfare of the natural world
3. Even in the middle of a city, I notice nature around me

Take Perspective

4. Humans have the right to use natural resources the way we want
5. Animals, birds and plants have fewer rights than humans

Emotional Empathy

6. I often think about the suffering of animals and plants
7. Some species are just meant to die out or become extinct

Physical Experience

8. I enjoy being outdoors, even in unpleasant weather
9. I often pay attention to the ambience of nature
10. I don't often go in a forest
11. I am very aware of environmental issues
12. Average time spend in nature per week

Appendix B – Interaction tasks

Please put your headphones and do the following tasks

1. Now, touch five of the plant's leaves, by focusing on each one's :
- bottom area;
- and then edges;
2. Now try to grab as much leaves as you can
3. Use the blue water tank to spray refreshing water on the plant's leaves.
4. Take the magnifying glass and carefully inspect the plant. Don't be afraid to look even in the strangest places
5. Now that you have inspected the plant, please cut approximately 1cm of a damaged leaf you spotted, using the scissors on the table, and put it in the pot next to the plant

Appendix C – Measurement tasks

Now, please take off the headphones.

The plant *Ornithogalum thyrsoides* is a South African flowering plant with long-lasting spikes of white blossoms that are shipped in to Europe and America for use as winter cut flowers. *O. thyrsoides* is a showy garden or container plant. It is poisonous to most cattle (horses, cows, etc.), if ingested heavily. It is ideal for export as the flowers keep well and have an extended vase life. The species prefer moist and fertile soil.

1. Please, set a price per pot for which, in your opinion, it should be sold. Put that in the field on your questionnaire sheet.
2. The pot seems to have less soil. Please, put a few spoons of soil in it from the pot with soil next to you
3. Put your name on a piece of paper and attach it to a leaf of the plant
4. Finally, read the following poem to it:

Your pain is the breaking of the shell that encloses your understanding.

Even as the stone of the fruit must break, that its heart may stand in the sun, so must you know pain.
And could you keep your heart in wonder at the daily miracles of your life, your pain would not seem less wondrous than your joy;
And you would accept the seasons of your heart, even as you have always accepted the seasons that pass over your fields.
And you would watch with serenity through the winters of your grief.
Much of your pain is self-chosen.
It is the bitter potion by which the physician within you heals your sick self.
Therefore trust the physician, and drink his remedy in silence and tranquillity.
(The Prophet, Kahlil Gibran)

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