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anihwa Project Progress Report

(FINAL)

DUE: FEBRUARY 2021

Project Title: **Toward a tool for farmers to evaluate welfare states of pigs: measuring vocal indicators of emotions**

Acronym: **SOUNDWEL**

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[1] Elodie Briefer was originally at ETH and moved to Copenhagen. She kept working on the Project.
[2] Edna Hillmann was originally employed by partner 6, and moved to Germany. She kept working on the project SOUNDWEL and so we added a seventh partner.

1. Summary of the project's progress

Consider each of the following items:

- *Main activities and achievements of the consortium*
- *Your opinion on the internal cooperation and added value to the project*

Please state if developments within the projects or outside have caused you to amend any of the project's goals and, if so, in what way

The collaboration between consortium partners has worked well, and each partner has been particularly efficient and active. We however encountered several issues (health, maternity, covid) that led us to extend the project for 1.5 years, without additional funding, and to adapt our strategy and define attainable goals. We could not achieve our goal of developing a tool, but we have collected sufficient data to develop it: acoustic cues that allow us to assess emotions (task 1), use of artificial intelligence to determine the usefulness of basing the tool on sonograms (additional to the expected outcomes of the project) (task 1), the technical background for the design of a tool (task 2), and novel recordings in controlled and naturally occurring situations made available for validation of a future tool (task 3).

The database of pig recordings, which served for the meta-analysis and could serve for developing a future recognition tool, has been completed with both existing recordings from all the partners and with additional recordings in an enriched situation, during play as well as in an assumed aversive situation, i.e. slaughter house (tasks 1.1. and 1.2). We succeeded in collecting more than 38000 calls recorded from 26 contexts, which are now on a database. About 17000 were selected (good quality) and acoustic cues were extracted (1.3.). We believe this is the largest database of pig calls available. This led us to be able to extract the relevant acoustic cues on which an automatic tool could be developed.

The requirements of the emotion recognition system have been discussed and agreed upon during the annual meeting 1 (task 2.1). The definition of the classification method (task 2.2) and the software design (task 2.3) could not be completely done due to several issues (see 4.). We thus adapted the plans and took advantage of the possibility to use STREMODO, previously developed by P3. This software, which is designed to record vocalisations in real-time, was modified to enable the analysis of pre-recorded and selected calls, so that it can be used in real-time on farm or with existing recordings. The implementation of additional analysis parameters has been prepared (MatLab code written and implementation in the LabView environment successfully tested). In task 2.3., a sensitivity of 86% was documented for STREMODO in detecting situations seriously decreasing piglets welfare, i.e. situations that included fights for teats, inability of a piglet to access a teat and a piglet being stepped upon by the sow or trapped under her body. Thus, the original STREMODO has sufficient sensitivity to be a useful one-channel monitoring tool of emergency situations in real on farm conditions. Task 3 was supposed to be devoted to the validation of the tool. We could not achieve it completely, and thus had to cancel task 3.3. However, we successfully achieved tasks 3.1. and 3.2. by developing a database of 18000 calls recoded in standardised situations of different valence and intensity, and 35h of recordings in situations commonly encountered in pigs (castration, slaughter, lactation).

SOUNDWEL finally led to 8 scientific publications, 19 conference presentations, 1 book chapter and several dissemination activities including TV show, popular articles, stands and teaching. Ruth Newberry, who attended our last meeting, is particularly interested in developing collaboration with the partners in the future, as well as IFIP (technical institute) in France. We will thus continue, depending on funding we can obtain, to try developing a tool for farmers and for research.

2. Achievement of planned objectives

Describe the activities that have been performed to meet the objectives set in the proposal.

WP1. DETERMINING VOCAL CORRELATES OF EMOTIONS

Task 1.1. Data gathering

Finalised. All partners uploaded their recordings to a platform (HOTCloud) hosted by P3, along with a detailed description of the context, the putative emotional valence and intensity induced in the subjects, and the subjects' details (e.g. identity, litter, age, sex).

Task 1.2. Additional recordings

Finalised. One of the planned additional recordings (pigs in handling situations) could not be performed (see *4. Problems and changes in objectives* for reasons). However, despite this missing situation, we obtained a database including calls recorded in 26 different contexts (from > 700 pigs), covering the major husbandry-related situations encountered by pigs from birth to slaughter, after adding the following recordings; a) positive and negative conditioning (P5), during which 32 pigs were conditioned to expect an enriched (positive) or a barren (negative) environment, followed by a running test, during which the same pigs were let free to run in a corridor; b) slaughterhouse recordings (P2), during which 19 groups of pigs were recorded in a French commercial slaughterhouse (< 5000 tons per year, 40 pigs slaughtered per h), during four different stages, including waiting (lairage), painful and not painful handling and introduction to the restrainer conveyor. The final database is comprised of over 38000 calls recorded in both assumed positive contexts of various intensities (e.g. from nursing to play) and assumed negative contexts of various intensities (e.g. from isolation to slaughter). We thus decided at the annual meeting 2 (Oslo, Sept 2017) that the database was complete and sufficient for carrying out the meta-analysis. The complete database will be made available on a platform like datainrae (https://data.inrae.fr/) once the article will be published. The additional recordings carried out by P5 will lead to a publication (In preparation).

Task 1.3. Identification of vocal indicators of emotions – meta-analysis

Finalised. In total, a student and a technician from P1 analysed 7414 calls produced by 411 pigs in 19 different context categories (made of the 26 original ones). Statistical analyses, performed by P6, showed that the assumed emotional valence of the contexts of vocal production, and the contexts themselves, could be correctly identified above chance levels from a limited set of vocal parameters. These results suggest that an automated recognition system, based on the most promising parameters (duration, amplitude modulation and spectral centre of gravity), can be developed for this highly commercial species to allow a real-time discrimination of emotional states as positive or negative. The resulting paper, authored by all teams, is now closed to submission (expected submission in March 2021).

WP2. DEVELOPING THE RECOGNITION TOOL

Task 2.1. Analysis of needs

Finalised. The requirements of the emotion recognition system were discussed during the first annual meeting. It was decided, based on the experience from the various partners regarding feasibility and practicability of the tool for farmers, that the tool should be able to identify three broad emotional states; 1: positive states, 2: negative low arousal states, 3: negative high arousal states. In addition, the tool likely needs input about the context of recordings, the breed and age of the pigs to be able to perform this classification. Such information could be entered by the farmer when using the tool. The tool would likely not be able to identify individual pig emotions, but instead give the farmer a warning when it identifies problematic vocalisations in a barn.

Based on the results of the analyses in WP1, the list of needs was adapted. Recording contexts could be classified reliably, and breed differences did not affect call characteristics to a degree relevant for the software, which suggests that the user will not have to provide this information. WP1 showed that separated analyses for high- and low-pitched calls results in better classification rates. Separated networks will thus have to be trained for these two call types, and therefore, a first analysis that identifies the spectral centre of gravity will have to be added in the software. However, this had been

anticipated from the beginning and is not difficult to implement. The output, on the other hand, will provide information on valence and context, while arousal might not be reliably detectable.

Task 2.2. Definition of the classification method; Task 2.3. Software design

Not finalized. P3 worked on the modification of the existing software STREMODO to fit the requirements of the new tool. After the third annual meeting, the original STREMODO has been made available to all consortium partners. This software, which is designed to record vocalisations in real-time, was modified to enable the analysis of pre-recorded and selected calls, so that it can be used in real-time on farm or with existing recordings. The implementation of additional analysis parameters has been prepared (MatLab code written and implementation in the LabView environment successfully tested). Due to two long-term sick leaves of P. Schön, who designed STREMODO and was responsible for its modification, the maternity leave of Postdoc 2, and delays in the meta-analysis (long-term sick leave of Postdoc 1), we unfortunately did not end up with a working prototype of the software (*see 4. Problems and changes in objectives*).

However, some measures were taken by the consortium to comply with the original goal of the project in building an automated tool. To this aim, a research assistant working with P6 (paid through external funds) applied machine learning algorithms (neural network) on the calls gathered in our database to investigate if other technologies than the one STREMODO is based on could serve as a basis for such tool. This method, based on images of the calls (spectrograms), achieved an accuracy as high as 89% for the classification of calls to the correct valence and 83% for the classification of calls to the correct context category. Further tests revealed that these percentages were not strongly affected by the background noise, which differs between each experiment. These results are very promising and provide the basis for further projects aimed at developing such a tool. These results were integrated in the meta-analysis paper (task 1.3), which is close to submission.

Task 2.4. Use of the prototype

Not finalized. Since the tool was not finalised, instead of the prototype, the original STREMODO software was used by P4. Acoustic track was collected on farm in a farrowing room housing 4 lactating sows and their 4-24 days old suckling piglets over four 7 hour periods spread over 4 days. In parallel, detailed videorecording was run of each sow and her litter with the aim to validate the ability of STREMODO to monitor negative valence situations in suckling piglets. A sensitivity of 86% was documented for STREMODO in detecting situations seriously decreasing piglets welfare, i.e. situations that included fights for teats, inability of a piglet to access a teat and a piglet being stepped upon by the sow or trapped under her body. Thus, the original STREMODO has sufficient sensitivity to be a useful one-channel monitoring tool of emergency situations in real on farm conditions.

WP3. TESTING AND IMPROVING THE RECOGNITION TOOL

Task 3.1. Validation in standardised tests

Not finalized. The aim of this part was to test how well the tool prototype classifies the vocalisations to the same emotion as indicated by the recording situation, and describe instances when the tool was not accurate. However, since the tool was not finalised (see Task 2.3), this validation could not be done. Instead, further recordings were collected in standardised tests in order to allow us, in the near future, to test a potential new tool (e.g. based on the machine learning algorithm developed in task 2.3) on these new sounds. The following recordings were collected and added to our database:

1. Recordings related to isolation, social and pseudo social reunions:

A social cognition and learning experiment was carried out on 60 weaned piglets. Each piglet learned to associate a signal to the reunion with either their conspecifics or their familiar human. Standard isolation/reunion tests with a human were also added to the protocol.

1.1. Recordings during associative learning period: for each piglet, 12 trials per (pseudo)social partner were carried out with an isolation phase (10 to 30 sec), an anticipation phase (2 to 20 sec from trial 1 to trial 12), and a reunion phase (2min) with each of the partner type (either two pen mates or the human, which actively tried to pet the piglets). In total, about 60 hours of recordings in standard conditions during the learning period were collected. Manual extraction of vocalisations on 15 hours of these recordings allowed to extract ~10000 calls of different types (low frequency grunts being the majority of it), giving insight on the quantity of individual calls available in these recordings.

1.2. Recording during isolation/reunion tests with a human: for each piglet, 2 isolation/reunion tests were carried out before and after the conditioning After a 5-minute isolation, piglets were reunited with a silent and immobile human for 5 other minutes. In total, these recordings represented 20 hours of acoustic data collection. For all of these recordings, manual extraction of vocalisations allowed the collect ion of ~12000 calls of different types, giving an idea of quantity of calls. Because all of these calls were manually labelled over time and classified according to the call type by an expert, they represent a dataset to validate both automatic extraction of vocalisations along time but also classification of contexts. The results have been published.

2. Recordings related to enriched situations (a human or manipulable object):

After being tamed by a human and familiarised with a manipulable object used as enrichment, 24 piglets were individually subjected to isolation/reunion tests either with the human, the object or remained alone for 5 more minutes. Each of the 24 piglets was subjected to the three tests, allowing a within subject comparison. Recordings represented 12 hours of recordings. Because all of these calls were manually labelled over time by an expert, they represent a dataset to validate both automatic extraction of vocalisations over time but also classification of contexts. For all of these recordings, manual extraction of vocalisations allowed the collection of ~6000 grunts to be used as validation dataset. The results have been published.

Task 3.2. Validation-Real condition tests

Not finalized. For the same reasons as mentioned above (3.1.), the validation could not be achieved and we instead collected new recordings to add to the database for future validation, as follows:

1. Recordings at slaughter :

Recordings were carried out in two commercial French slaughterhouses (< 5000 tons per year, 40 pigs slaughtered per h) during routine slaughter. A total of 3935 s of call were recorded, corresponding to 496 call sequences. Recording of pigs sounds were carried out during the same four different situations, as in the WP1. In the slaughterhouse 1, calls were also recorded during an additional situation, when pigs are waiting in the lairage area without human presence.

2. Furthermore, P3 recorded vocalisation during castration of 134 piglets with five different treatments, which are still undergoing analyses.

3. Acoustic track was collected on farm in a farrowing room housing 4 lactating sows and their 4-24 days old suckling piglets over four 7 hour periods spread over 4 days. This allowed us to record currently occurring negative situations that included fights for teats, inability of a piglet to access a teat and a piglet being stepped upon by the sow or trapped under her body.

All these data and recordings are now available on our platform (HOTCloud), and will be available for a future project we could work on together.

Task 3.3. Validation: Accuracy measurements and improvements

Not finalized. For the reasons mentioned above (3.1.), this task was not completer. However, we hope to use the additional recordings collected in tasks 3.1. and 3.2. for validation of a tool developed based on machine learning algorithms in the near future, if further funds are obtained to continue our collaboration.

Task 4.1. Internal communication

As P1 was not present for the first 18 months of the project, P6 took the responsibility of coordinating the project for this period, and then P1 and P6 coordinated together the last 36 months. Regular phone and skype meetings were organised, with all partners or between partners working on the same task. Annual physical meetings were organised (1: by P6, 2: by P5; 3: by P3) until sanitary situation (COVID 19) constrained us to organised the last meeting remotely (4 and 5: by P1).

In-between. Six other virtual meetings with all partners were organised to discuss progress of each task, and plan for the next steps. We also organised monthly email updates from May 2018 to December 2018, a period when we had a lot of activities and needed regular exchanges. A final meeting was also organised in late November 2020 to discuss possibilities for further collaborations, notably with Ruth Newberry from NMBU.

Task 4.2. External scientific communication

Nine scientific articles (+ 1 to be submitted) were published by the partners, and a total of 19 communications (talks, posters) were presented. A session was organised by P1 and P6 at the International Bioacoustics Society conference in 2018, UK. P1, P3 and P6 also wrote a book chapter together.

The different partners attended several events to popularise and teach about SOUNDWEL (see 5.).

The website of the project is available from February 2020 at https://www.soundwel-project.eu/. People can find information in English about the aims and outputs of the project, and about the partners.

We could invite Ruth Newberry (NMBU) at our last meeting, and she showed real enthousiast about our project, and we had the opportunity to discuss further collaboration possibilities (EU projects for instance).

Task 4.3. Communication to stakeholders.

This task devoted to stakeholders could not be realised, as we have no tool to discuss. However, we keep on trying to find stakeholders interested. In France, IFIP is interested in trying to detect tail biting with sounds for instance.

3. International collaboration added value

Describe the activities that have been accomplished in collaboration within the consortium. Refer explicitly to joint milestones and deliverables produced.
Describe any sharing of facilities, databases within the consortium.

The following milestones have been reached:

M1.1. Prepare database for storage of vocal, behavioural and physiological recordings of existing data (all partners)

M1.2. Permissions to run animal experiments granted (for experiments that were performed, see *4. Problems and changes in objectives*) (P1 SUBCONTRACTOR and P5)

M1.3. Data collected and ready for analyses (for experiments that could be performed, see *4. Problems and changes in objectives*) (P1 SUBCONTRACTOR, P2 and P5)

M1.4. Vocal analyses completed (P1)

M1.5. Meta-analysis of all recordings completed (P6)

M2.1. List of requirements (all partners)

M2.2. Decision on parameter sets and network specifications (P3)

M3.1. Permissions to run animal experiments granted (P1-4)

M3.2. Data collected (P1-4)

M4.1. Annual meeting 1 (all partners)

M4.2. Annual meeting 2 (all partners)
M4.3 Annual meeting 3
M4.5 Annual meeting 4 with external scientist

The following milestones have not been reached (see *4. Problems and changes in objectives* for *reasons*):
M2.2 Prototype of the emotion recognition software tool
M2.4. All partners trained and ready to use the prototype
M2.5. Manuals written
M3.3. Results collected from all teams
M3.4. Finish calculation of tool accuracy
M 3.5. Finalised recognition tool
M4.4 Contact stakeholders

The following deliverables are finished:
1.1. Comprehensive database of recorded vocalisations, behaviour and physiology (all partners)
1.2. M10 One popular report on the work planned for validating vocalisations as a welfare indicator (P5 and P6)
1.3. Recordings of pigs in rewarding situations for later meta-analysis (P5)
1.4. Recordings of pigs in play situations for later meta-analysis (P5)
1.6. Recordings of pigs in slaughter-related situations for later meta-analysis (P1 SUBCONTRACTOR and P2)
1.7. M15 One popular report exemplifying vocalisations as a suggested tool for monitoring welfare in pigs (P1)
1.8. One popular lecture or report summarizing findings for stakeholders (lecture, by P5 and P6)
1.9 Peer-review paper on vocal indicators of pig vocalisations (all team; close to submission)
4.1. Annual report 1 (report of the Annual meeting 1) (P6)
4.2. Annual report 2 (report of the Annual meeting 2) (P6)
4.3 website opened (P1)
4.5 Annual report 3

Unachieved deliverable (see *4. Problems and changes in objectives* for reasons and alternative plans)
1.5. Recordings of pigs in handling situations for later meta-analysis (P1)
2.1 Prototype of emotion recognition software tool
2.2 Article on the emotion recognition tool
3.1 Report on the correct classification instances from the validation-Standardised tests.
3.2 Tool prototype accuracy
3.3 Final version of the recognition tool
4.4 Demonstration of the tool to the stakeholders

4. Problems and changes in objectives

Describe any difficulties and problems that have hindered the achievement of the planned objectives and any alternative plans or changes with respect to the original proposal.

Soundwel suffered from an unusually large number of central participants being on leave since the beginning of the project (June 2016). In some cases, there has not been any possibility to replace

them within their team (only these cases are listed below). In addition, other teams encountered issues with the provision of the funds. These problems have led to the following delays and alternative solutions decided upon:

P1: C. Tallet (project coordinator) was on maternity leave for 6 months, and health leave for 13 months (June 2016-Jan 2018).

Impact: C. Tallet could not perform the experiments planned in 2017 (task 1.2.). As a result, the deliverable 1.5 (Recordings of pigs in handling situations for later meta-analysis) could not be provided.

Alternative plan: The coordination of the project was carried out by E. Briefer (ETH Zürich; P6). P1 used the situation of pigs in handling situations as a validation situation in task 3.1, instead of for the database.

P3: L. Leliveld (Postdoc 2) was on maternity leave from Jan 18 to Mar 19 (hired with Soundwel funding Jan-June 2018, hired by the FBN afterwards), and P. Schön (responsible for developing the emotion recognition tool with Postdoc 2) was on health leave for 10 months (Jan-Oct 2017) and then from August 2019 until now.

Impact: The prototype for the emotion recognition tool (expected Month 23) could not be finalised.

Alternative plan: P3 replaced Postdoc 2 during her leave, to get support both with the software design and with the meta-analysis. In addition, the consortium identified a potential consultant (http://www.maisha-group.com/), who could build an alternative tool with the desired features, but unfortunately this solution was not feasible with the limited financial resources available. As described in task 2.2. above (Achievement of planned objectives), P6 also hired a research assistant for 5 months (Sept 2020-Jan 2021) using external funds to test the potential of machine learning algorithms for building such tool in the near future, and the results are highly promising.

P4: M. Spinka (P4) encountered some delay with the delivery of the funds promised by the Czech Republic Minister for the project.

Impact: This led to the impossibility to perform the experiments planned in 2017. As a result, the deliverable 1.4 (Recordings of pigs in play situations for later meta-analysis) could not be provided.

Alternative Plan: Postdoc 1 (P5) recorded pigs during an additional experiment, while they were running back and forth in a corridor and producing play barks. These recordings were added to the database to replace those from P4.

P5: M. Padilla de la Torre (Postdoc 1, P5) was on sick leave from Oct 2017 to the end of the project.

Impact: Postdoc 1 built the database (Deliverable 1.1) along with the other partners and provided the deliverable 1.3 (Recordings of pigs in rewarding situations for later meta-analysis) and 1.4 (Recordings of pigs in play situations for later meta-analysis). However, she was not able to complete the meta-analyses (Milestones 1.4 and 1.5, planned for Months 15 and 16).

Alternative Plan: All the partners identified students and technicians who could help with the analyses of the recordings and the meta-analysis, in order to prevent further delays. This allowed all sounds from the database to be analysed, which was followed by statistical analyses carried out by P6 instead. This task has thus been completed and led to the writing of a paper, which is closed to submission.

Because of all these unexpected delays, we asked ANIHWA for a one-year extension of the project duration, which was granted on 26.01 by Stefan Lampel on behalf of the ANIHWA

consortium. Following further delays cause by Covid-19, 6 additional months were granted by ANIHWA and the project thus officially ended in Nov 2020.

5. Project-derived publications and patents

*Publications **with** the involvement of other partners of the consortium*	**Scientific articles:** Baciadonna L, Düpjan S, Briefer E, Padilla de la Torre M, Nawroth C. 2018. Looking on the bright side of livestock emotions—the potential of their transmission to promote positive welfare. Frontiers in Veterinary Sciences 5:218. doi: 10.3389/fvets.2018.00218 Briefer EF, Vizier E, Gygax L, Hillmann E 2019. Expression of emotional valence in pig closed-mouth grunts: Involvement of both source-and filter-related parameters. The Journal of the Acoustical Society of America 145, 2895-2908. Briefer E, Linhart P, Policht R, Špinka M, Leliveld LMC, Düpjan S, Puppe B, Padilla de la Torre M, Janczak AM, Bourguet C, Deiss V, Boissy A, Guérin C, Read E, Coulon M, Hillmann E, Tallet C. 2019. Vocal expression of emotional valence in pigs across multiple call types and contexts. PeerJ Preprints 7:e27934v1 https://doi.org/10.7287/peerj.preprints.27934v1 Villain AS, Hazard A, Danglot M, Guérin C, Boissy A, Tallet C 2020. Piglets vocally express the anticipation of pseudo-social contexts in their grunts. *Scientific reports*, *10*(1), 1-13. Data published at *Portail Data INRAE* https :// doi.org/10.15454 /C4JRPP (2020). Briefer E, Boissy A, Bourguet C, Deiss V, Düpjan S, Guérin C, Hillmann E, Janczak AM, Leliveld LMC, Linhart P, Padilla de la Torre M, Rasmussen JH, Read ER, Špinka M, Tallet C. close to submission. Acoustic indicators of emotional valence in pigs. Will be submitted to Proceedings of the National Academy of Sciences of the United States of America in March 2021. **Conferences:** Briefer EF, Gygax L, Hillmann E 2016. Vocal expression of emotions in pigs. 50th Congress of the International Society for Applied Ethology, Edinbourgh, UK. Padilla de la Torre M, Briefer EF, Nordgreen J, Andrew AJ 2017. SOUNDWEL: Toward a tool for farmers to evaluate welfare states of pigs: measuring vocal indicators of emotions. NMBU Animal Welfare Seminar, Oslo, Norway. Padilla de la Torre M, Janczak A, Nordgreen J, Boissy A, Bourguet C, Coulon M, Düpjan S, Hillmann E, Špinka M, Tallet C, Briefer E 2017. The ERA-Net ANIHWA project SOUNDWEL: determining vocal correlates of emotions in domestic pigs. XXVI International Bioacoustics Council meeting, Haridwar, India. Briefer EF, Linhart P, Policht R, Špinka M, Leliveld LMC, Düpjan S, Puppe B, Padilla de la Torre M, Janczak AJ, Bourguet C, Deiss V, Boissy A, Guérin C, Read E, Coulon M, Hillmann E, Tallet C 2019. Vocal expression of emotional valence in pigs across multiple call types and contexts. 2019. 2nd Workshop on Vocal interactivity in-and-between Humans, Animals and Robots, London, UK. Villain AS, Hazard A, Guérin C, Alain B, Tallet C 2019. Vocal expression of emotions in pigs during anticipation of positive social contexts: impact of human animal relationship. XXVII International Bioacoustics Council meeting, Brighton, UK. Villain A, Hazard A, Boissy A, Guérin C, Tallet C 2019. Variabilité de l'expression vocale des porcelets lors de l'anticipation d'évènements positifs et négatifs. Congress of the French Society for the study of Animal Behaviour (SFECA), Lille, France.

	OTHER ACTIVITIES: **Public talk**: Padilla de la Torre M, Briefer EF, Nordgreen J, Andrew AJ 2017. SOUNDWEL: Toward a tool for farmers to evaluate welfare states of pigs: measuring vocal indicators of emotions. Ås Kulturhus, Ås, Norway **Conference symposium**: Briefer EF, Tallet C, Villain AS 2019. Vocal expression of emotions. XXVII International Bioacoustics Council meeting, Brighton, UK. **Book chapter:** Tallet, C, Leliveld, LMC, Briefer EF 2019. Vocalizations. In X. M. Vilanova (Ed.), Animal welfare in practice: pigs. **Talk at PhD course:** Tallet, C, Leliveld, LMC, Briefer EF 2019. Indicators of emotions : vocalisations. ISAE course on animal emotions, Wageningen University, Netherland. **Press release**: https://www.inrae.fr/en/news/animal-welfare-humans-objects-conspecifics-piglets-tell-us-what-they-prefer
*Publications **without** the involvement of other partners of the consortium*	**Scientific articles** Leliveld LMC, Düpjan S, Tuchscherer A, Puppe B (2017) Vocal correlates of emotional reactivity within and across contexts in domestic pigs (*Sus scrofa*). Physiology & Behavior 181:117–126. doi: 10.1016/j.physbeh.2017.09.010 Leliveld LMC, Düpjan S, Tuchscherer A, Puppe B. 2020. Hemispheric specialization for processing the communicative and emotional content of vocal communication in a social mammal, the domestic pig. Frontiers in Behavioral Neuroscience, section Emotion Regulation and Processing 14, 217. Villain AS, Lanthony M, Guérin C, Tallet C 2020. Manipulable object and human contact: preference and modulation of emotional states in weaned pigs. Frontiers in veterinary science, 7. Data published at Portail Data INRAE https://doi.org/10.15454/GDLDBH (2020) **Talks:** Briefer EF 2016-2020. 12 invited talks on vocal expression of emotions across species, mentioning SOUNDWEL project; Université Jean Monnet (France – 2020); Acoustic communication: an interdisciplinary approach (Brazil – 2020); University of Exeter (UK – 2020); University of Copenhagen (Denmark – 2019); University of Copenhagen (Denmark – 2018); Université Laval (Canada – 2018); Koret School of Veterinary Medicine (Israel – 2018); Norwegian University of Life Sciences (Norway – 2017); Lincoln University (UK – 2017); Portsmouth University (UK – 2017); Anglia Ruskin University, Cambridge (UK – 2017); Tel Aviv University (Israel – 2017). **Talk at PhD course:** Tallet C 2019. Human-animal relationships and emotions. ISAE course on animal emotions, Wageningen University, Netherland. **Dissemination:**

	Hillmann E 2019. Stand on pig vocalisations, summer party of the employees, Humboldt-Universität zu Berlin. Düpjan S 2019. 'Die Stimmung in der Stimme', Open doors of FBN. Tallet C 2019. Stand of INRA at the Agriculture International Show of Paris. Communication sonore des porcs. Briefer EF 2019. Stand at 'Culture Night', Copenhagen**.** 'Does it sound positive or negative? From horses to pigs, how good are you at recognising animal emotions from their sounds?' Les porcs donnent de la voix. In : dossier de presse INRA du salon de l'agriculture. P7 Sciences Ouest : Comprendre les émotions du cochon. Sciences Ouest du mois d'avril 2019 par Guillet, M. p10
*Patents **with** the involvement of other partners of the consortium*	no
*Patents **without** the involvement of other partners of the consortium*	no

6. Brief financial report

Each partner spent the following amounts from the Anihwa budget (in Euros).

	Partner 1	***Partner 2***	***Partner 3***	***Partner 4***	***Partner 5***	***Partner 6***	***Total***
Personnel	64125.62	17 173.8	93334.05	13638.65	94014	17549.51	94014
Equipment + travel	28457.69	1069.3	6171.42	3161.62	8750	0	8750
Other costs	44406.75	0	0	3306.07	55319	718.87	55319
Total	136990.06	18 243.1	99505.47	20106.33	158083	18268.38	158083

7. Executive summary

Emotions play a central role in modern definitions of farm animal welfare. Therefore, it is of special interest to reliably detect them in practice. One promising approach to this is the analysis of vocalisation, which often accompanies emotional responses as part of the behavioural component of affect. On the one hand, calls may be used as highly referential signals, i.e. call types or sub-types are specific to a context or affective state. On the other hand, the quality of calls may show subtle but significant within call type variation between contexts or states. Our project aimed at the development of a software tool to detect and quantify such bioacoustics indicators of emotion in pig vocalisation. This required the identification of reliable indicators across different breeds and ages (both factors known to significantly affect vocal quality), and their implementation in a software-environment for real-time monitoring in practice based on artificial neural networks. To achieve this, we formed a consortium of six partnering institutes with a strong background in pig vocalization and emotion. The partners contributed to a database comprising over 38,000 calls produced in 19 different context categories by pigs housed in five different facilities. Data originated mostly from previous published research studies, and were supplemented with new recordings from contexts (and therefore affective states) that were still lacking but relevant on-farm. Statistical analyses were run across this database, aiming to find both indicators of context and of valence and arousal. Call duration and amplitude modulation turned out to be good indicators of emotional valence (i.e., how pleasant of unpleasant/positive or negative a situation is perceived by the animal). Calls produced in positive contexts were shorter and less modulated. Using discriminant function analyses, we could show that calls could be reliably assigned (with > 97% accuracy) to the context of production. This

indicates that they could most likely be correctly classified using artificial neural networks as intended in our software tool. A separate analysis for high-pitched (squeals, screams) and low-pitched (grunts) calls appears to improve classification and would therefore need to be implemented in the software. Because of significant shortfall of personnel due to illness and parental leaves of key members of the involved working groups, we could not finish the software prototype and test it in practice. First results on artificial network training with a data-subset were promising, though. However, despite all efforts to make up for the personnel shortfalls, we failed to reach our final goal, but we still consider the database we gathered a significant accomplishment. Artificial neural networks and machine learning approaches in general require enormous datasets, which in this specific context could not be generated by a single group alone. Amongst others, one needs to record the same context in different facilities and different breeds in order to avoid the algorithm learning to identify these instead of the affective state in focus. Within SOUNDWEL, we were able to do this, so the database is an exceptional basis for future developments. On the final project meeting, the project partners evaluated ways to pursue their work in the future, and are indeed already working on alternative machine learning approaches to implement in a software.

I declare that the information I have given is correct to the best of my knowledge and belief.

Céline Tallet	15/02/2021
Name	*Date*

coordinator of SOUNDWEL
Position held