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Human-animal interactions during on-farm truck loading of finishing pigs for slaughter transport

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HIGHLIGHTS

- Rough handling by drivers increase the odds of stress related pig behaviour.
- Rough handling by drivers increase the odds of a disrupted pig flow.
- Stress related pig behaviour increase the odds of rough handling by drivers.
- Gentle handling by drivers increase the odds of relaxed pig body positions.

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ABSTRACT

Finishing pigs and transport drivers (TDs) interact closely when pigs are loaded for transport, which can be very stressful for both. We aimed to investigate relationships between TD handling actions and pig behaviours during loading for slaughter transport. In total 2,476 finishing pigs were loaded by 18 TDs (2 women, 16 men) during 18 loadings at 18 pig farms in Sweden over a 6 month period. Tactile, vocal and visual TD handling actions were recorded and characterized as 'moderately-strongly negative', 'mildly negative' or 'positive'. In the pigs, 'stress related', 'flow', 'disrupted flow' and 'relaxed' behaviours were recorded in all animals within 2 m in front of the TDs, using continuous video recordings, and summarized in 5-s intervals. Logistic models were constructed to estimate associations between actions and behaviours, including the preceding one or two intervals. The odds of stress related behaviour in the pigs was found to increase 5.4 and 4.1 times when a moderately-strongly negative and any negative TD action, respectively, occurred in the same interval. When a moderately-strongly negative and any negative TD action occurred in the preceding interval, the odds of stress related behaviour increased 2.0 times and 1.4 times, respectively. The odds of disrupted flow increased 1.6 times when any negative TD action occurred in the same interval. Furthermore, the odds of moderately-strongly negative TD action increased 5.4, 3.4 and 1.9 times, and the odds of any negative TD action increased 3.6, 2.9 and 2.1 times when stress related pig behaviour occurred in the same interval, the preceding interval and the interval before that, respectively. Positive TD action in the same or preceding interval was associated with relaxed pig behaviour. This study suggests a reciprocal relationship between TD actions and pig behaviour, which provides an opportunity to improve TD actions through training in order to reduce stress behaviours in pigs.

1. Introduction

Slaughter transport and related handling can be one of the most stressful events in the pig's life. Globally, about 1.5 billion pigs are slaughtered each year (FAO, 2022). In Sweden, approximately 2.6 million pigs are reared for pork production each year and transported from farms to abattoirs (Swedish Board of Agriculture, 2022), by approximately 100 transport drivers (TDs) (pers. comm., A. Falk., Swedish Association of Road Transport Companies, 18 June 2020). Societal concerns about animal transportation have increased, especially with regard to animal welfare during loading and unloading (Vanhonacker et al., 2009, 2012). We previously found that loading of pigs can

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be a stressful and complex task for the TD, who needs to adjust to conflicting stakeholder and regulatory requirements, varying on-farm conditions and working tasks that can be both uncomfortable and strenuous (Wilhelmsson et al., 2021).

The main pig welfare risks in the pre-slaughter process are associated with pre-transport farm management such as marking, fasting and mixing groups of unfamiliar pigs before transport as well as rough handling, poor staff skills and inadequately designed facilities (Dalla Villa et al., 2009; Goumon and Faucitano, 2017; Faucitano, 2018). Aversive handling of pigs by stockpersons during rearing leads to increased fear of humans (Hemsworth and Barnett, 1991) and acute stress responses to human contact (Hemsworth et al., 1981, 1986). There are causal relationships between handler attitudes and behaviour towards pigs and pigs' fear of humans (Hemsworth and Coleman, 2011). Negative handling is also likely to have an indirect effect on the handler, such as a decrease in job satisfaction through difficulties in handling fearful animals and reinforcing negative attitudes towards pigs and handling of pigs (Hemsworth and Coleman, 2011; Hemsworth et al., 2018). Pigs with brief and mainly negative experiences of humans are likely to generalize and extend their behavioural fear responses also to unknown humans (Hemsworth et al., 1994a). Regular positive interactions, on the other hand, reduces pigs' fear of humans (Hayes et al., 2021).

The exposure to novel environments during loading can cause stress responses in pigs, as can low or high ambient temperatures, bright sunlight, precipitation and wind (Grandin, 2019). This can lead to behavioural responses such as baulking, turning back, backing away or vocalizing, which are indicative of aversion (Broom, 2019). Escape behaviours, which may also be caused by fear of the human handler, as well as fear responses to novelty such as unfamiliar locations, makes pigs more difficult to move and reduces time efficiency when moving them (Hemsworth et al., 1994b; Hemsworth, 2019). The multiple stressors during on-farm handling and truck loading can result in cumulative stress in the pigs and reduced ability to cope with subsequent production steps, i.e., transport, unloading, lairage and stunning. High stress levels and poor coping abilities may also lead to metabolic changes with subsequent deterioration in meat quality (Gregory and Grandin, 2007; Dokmanović et al., 2014; Faucitano, 2018). According to Faucitano (2018), low pig welfare during pre-slaughter and transport handling can be prevented by improving the facility design and the overall environmental conditions, and by implementing training programs for correct animal handling.

Modern pig transport vehicles have three or four hydraulic floors, and a full trailer-lorry carries about 300 pigs. Keeping pigs in intact groups from rearing to slaughter is known to reduce the risk of fighting during transport, with a subsequent lower risk of skin lesions and poor meat quality (Driessen et al., 2020). Also, handling pigs in small groups (<10) has been found to reduce fighting, increase ease of handling (Dalla Costa et al., 2019), prevent elevated heart rate and improve time efficiency (Lewis and McGlone, 2007). According to Swedish regulations on transport of live animals (SJVFS 2019:7) no more than 10 pigs may be handled at the same time. However, common work practices involve mixing of pigs to achieve uniform weights and adapt to the size of vehicle compartments that have room for 12–20 pigs.

During loading, the TD is presented with pigs that are brought out from the housing facility by farm staff. The number of pigs and loading area design, as well as animal characteristics, varies greatly between farms (Wilhelmsson et al., 2021). Rattle paddles and sorting boards are commonly used handling tools, with possible welfare implications (Correa et al., 2010). In Sweden, electric prods may only be used restrictively on adult pigs under certain conditions and thus not on 6 month-old finishing pigs. Sorting boards have been suggested as an effective moving device, provoking less pig vocalizations compared to paddles and prods (McGlone et al., 2004).

Research on pre-slaughter handling of pigs has mainly focused on attitudes and handling actions by abattoir personnel (Geverink et al., 1996; Coleman et al., 2003; Hemsworth et al., 2011, 2012), effects of lairage time and aversive handling on stress and reduced meat quality in pigs (Hemsworth et al., 2002; Dokmanović et al., 2014), and effects of season and truck type on pig behaviour during loading (Torrey et al., 2013). Although transportation and associated handling are major risk factors for impaired pig welfare (Geverink et al., 1998), and TDs handle most pigs reared, there is a lack of studies on TDs' handling methods and working routines during loading of pigs, and little is known about the interaction between TDs and pigs during on-farm loading.

The aim of this study was to investigate relationships between TDs' handling actions and the behaviour of finishing pigs that they load for slaughter transport. We hypothezised that negative handling actions increase pig behaviours indicative of stress and a disrupted flow, for example crowding, turning back or stopping and that pig behaviours indicative of stress increase negative TD actions. We also hypothesized that positive handling actions increase relaxed pig behaviours. This study was part of a larger project in which TDs time efficiency and physical workload were also examined.

2. Material and methods

2.1. Ethical statement

This study was approved by the Regional Ethical Review Board of Gothenburg (ref. 070–18) for human research subjects, and the Animal Ethics Committee of Gothenburg (ref. 5.8.18–12,650/2018) for animal research. Participation was voluntary and haulier managers, TDs, farmers and abattoir managers gave their informed consent before data collection.

2.2. Transport drivers, pigs and farms

Swedish large-scale abattoirs were asked to provide contact details to their contracted pig transporters, and these were approached for possible participation. Haulier managers provided contact details to individual TDs, who were contacted by telephone and asked to participate. Eighteen TDs (2 women and 16 men) aged 20–54 years, employed by four hauliers operating in southern, western and central northern Sweden, were included in the study, which accounted for approximately 15% of all pig TDs in Sweden. All participants had at least 6 months experience of commercial pig transportation. The selection of farms was based on the hauliers' normal schedule. The farmers were asked to participate by the haulier or a research technician on the day before the intended loading; 18 farmers agreed to participate. Between 49 and 258 pigs, three-way cross-hybrids aged approximately 6 months, both gilts and male castrates, were loaded at each occasion. Number of pigs were pre-decided according to farm practices and all loadings were the first in the workday of the TDs.

2.3. Recordings

Recordings were made from August 2018 to January 2019. Loadings were done between 04:30 and 14:00 h, usually in the morning. Information on farm management was collected from the farmers by telephone either the same day or the day before or after loading. Design of the loading area, ambient temperature and weather conditions were recorded immediately before and after loading. At half of the loadings there was no litter material on the floor in the loading area or on the truck ramp; in the remaining cases, straw or wood shavings was typically applied. The loadings were video-recorded using a camera (Hero 5 Black, GoPro, Inc., San Mateo, California, USA) that was attached to the side wall of the upper part of the ramp of the vehicle. The camera was directed towards the doorway through which the pigs exited the farm building, covering most of the loading area, i.e. the area between the doorway and the vehicle ramp, as well as a small part of the building's interior if this was included in the TDs work area. Three observers were positioned outside the loading area during loading. The loadings were carried out according to the usual routines for each farm and TD and precautions were taken not to disturb the TDs and pigs.

The ethograms of TD actions and pig behaviours were developed based on direct ad libitum observations of video recordings from 2 loadings. Following training using short video sequences, two authors blind to TD identity (JY or MA) coded all video recordings. Actions and behaviours were observed when both the TD and one or more pigs were present in the loading area. It was noted if farm stockpeople were present in the loading area at the same time as the TD. TD actions directed towards pigs were divided into the four categories: 'mildly negative' (light slap with tool), 'moderately-strongly negative' (moderate or forceful physical contact with hand, knee or foot or loud noise), 'any negative' (mildly or moderately-strongly negative) and 'positive' (light touch of hand, standing close without physically interacting, or using a soft voice). Pig behaviours were divided into four categories: 'stress related' (for example, running, high-pitched vocalizations or crowding), 'disrupted flow' (for example, stopping, turning or backing away from trailer), 'flow' (walking or turning towards trailer) and 'relaxed' (investigating environment and head below shoulders). Actions and behaviours are described in Supplementary Table 1.

Physical TD actions, except for physical contact with knee or foot, were recorded continuously with all occurrence sampling. Physical contact with knee or foot, auditory and visual interactions were recorded with continuous 1/0 sampling at intervals of 5 s. Only actions that were directed towards pigs within a half-circle with a radius of 2 m in front of the TD and behaviours displayed by these pigs were recorded (Fig. 1). The pigs within a half-circle within a radius of 2 m in front of the TD were denoted by a 'lot'. All actions and behaviours were regarded as events. Pig behaviours were recorded at the lot level (either no behaviour or one or more behaviours displayed in the lot). Eight binary composite variables expressed whether one or more of the recorded actions or behaviours were displayed one or several times in the interval (Supplementary Table 1). Each composite variable was supplemented by two additional variables that expressed corresponding values in the preceding 5-s interval and the interval before that (denoted 'lag -1′ and 'lag −2′, respectively).

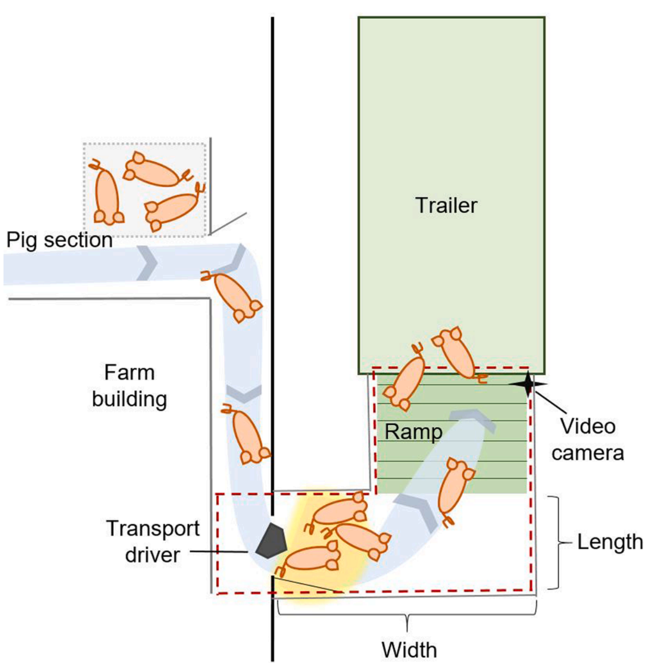

Fig. 1. Example of a loading area and positioning of the trailer. The dashed lines mark the loading area, based on the transport drivers working zone and video coverage. The half circle in front of the transport driver marks the area where pigs were included in video recordings.

For each recording of a TD action, the instantaneous lot size was also recorded. The number of pigs within 2 m in front of the TD was calculated for each interval, either as the mean of all recordings in the interval or, if no value was available, as the nearest preceding value from up to five earlier intervals in the same loading or, if required, as the mean of the complete loading.

2.4. Statistical analysis

Statistical analysis was made in Stata/IC 15.1 (StataCorp LLC, College Station, Texas, USA). Only intervals with recordings when both the TD and pigs were present in the loading area were included in statistical models. Periods of intervals where the light conditions were insufficient for reliable recordings were excluded.

Initially, Spearman rank correlation was used to investigate relationships between the recorded numbers of composite variables at both interval and loading levels. Mixed-effects logistic models were fitted (using the Stata *melogit* command). Two different models of stress related pig behaviour were estimated, as well as of disrupted flow, using either moderately-strongly negative TD action or any negative TD action as studied predictor. In a similar manner, two different models of TD actions were estimated using either moderately-strongly negative or any negative TD action as a dependant variable, and stress related and disrupted flow pig behaviours as studied predictors. A model of relaxed pig behaviour was estimated using positive TD action as a studied predictor. This resulted in a total of seven models (Table 1). In each case, studied predictors were expressed by three independent variables representing the same and preceding intervals (lag 0, −1 and -2), which were all forced into the models.

Twenty-two variables representing TD and environment characteristics, possibly confounding the studied relationships, were tested as fixed effects. To facilitate modelling, continuous variables were categorized into three to five approximately equally-sized categories: recorder id (JY; MA), total number of pigs loaded (49–84; 85–109; 110–164; 165–265), average number of pigs in one 5-s interval within 2 m in front of TD (1.0; 1.1–2.0; 2.1–3.0; 3.0–10), haulier (a; b; c; d; e), TD gender (male; female), TD age (21–25; 26–29; 30–34; 35–55 y), rearing time (70–90; 91–103; 104–114; 115–127 days), sorting of pigs by farm staff before loading (no; yes); time fasting pigs before loading (0–3; 5–8; 9–12 h), season (Aug.–Nov.; Dec.–Mar.), hour of day when loading started (before 4:00–5:59; 6:00–6:59; 7:00–8:59; 9:00–12:00; 12:00–16:59 h), weather conditions (calm; rain, strong sunshine or strong wind), outdoor temperature (−4–+2; 3; 4–5; 6–12 °C), paddle use

Table 1
Dependant variables and studied predictors of models of relationships between transport driver (TD) actions and pig behaviours during on-farm truck loading of Swedish finishing pigs for slaughter transport.

Dependant variable	Studied binary predictors
Stress related pig behaviour	Moderately-strongly negative TD action in the same 5-s interval, the preceding interval and the interval before that
Stress related pig behaviour	Any negative TD action in the same 5-s interval, the preceding interval and the interval before that
Disrupted pig flow	Moderately-strongly negative TD action in the same 5-s interval, the preceding interval and the interval before that
Disrupted pig flow	Any negative TD action in the same 5-s interval, the preceding interval and the interval before that
Relaxed pig behaviour	Positive TD action in the same 5-s interval, the preceding interval and the interval before that
Moderately-strongly negative TD action	Stress related pig behaviour and disrupted pig flow in the same 5-s interval, the preceding interval and the interval before that
Any negative TD action	Stress related pig behaviour and disrupted pig flow in the same 5-s interval, the preceding interval and the interval before that

on farm daily management (no; yes), width of loading area (60–139; 140–234; 235–319; 320–400 cm), length of loading area (0–149; 150–184:185–322; 323–685 cm), corners in loading area (none; soft; sharp), floor surface of loading area (concrete; soil; wood), slope of loading ramp (4.0–9.2; 9.3–12.9; 13.0–16.6; 16.7–22.2°), width of loading ramp (60–148; 149–169; 170–185; 186–235 cm), length of loading ramp (140–247; 248–269; 270–274; 275–347 cm) and floor surface of loading ramp (metal; non-slip). In addition, a dichotomous variable expressing farm staff present in loading area during recording in the same or two preceding intervals (no; yes) was considered for inclusion. Rearing time was used as a proxy for average pig size. Pre-sorting, instead of emptying of the pig section, was done in approximately half of the loading due to split marketing.

A random effect for loading occasion was introduced to account for clustering. However, in most models, the random effect was eliminated because the fixed effects accounted for virtually all variation between TD and loadings, rendering random estimates impossible to obtain. Thus, the models were simplified by excluding unnecessary random factors. This simplification changed the model estimates only marginally (to the 4th-8th decimal). The variances were partitioned at different data levels for empty models with random effects using the latent-class method (assuming the residual variance to be $\pi^2/3$) and the intraclass correlation coefficients were calculated.

The studied predictors were forced into the models. All potentially confounding variables were tested one by one in univariable models with random loading, and only those significant at $p \leq 0.20$ were considered as eligible for further modelling. Subsequently, models with all eligible variables were reduced by a manual stepwise procedure, in each step excluding the variable with the highest p value and trying to reenter one-by-one all the previously excluded variables, until all remaining variables were either significant at $p \leq 0.05$ or confounded one or several of the studied predictors, as judged by a change in regression coefficients by >10% when the confounder was excluded (given that the changed coefficient was significant at $p \leq 0.10$ before or after the exclusion). Interactions between fixed effects were disregarded.

Model diagnostics included the Pearson χ^2 test, delta-beta influence statistics (Pregibon, 1981) and the area under the Receiver Operating Characteristic curve as measures of goodness-of-fit and discriminative ability. Overdispersion was estimated by calculating the Pearson χ^2 divided by its degrees of freedom. To check for the influence of overdispersion, the models were run with a generalized linear model framework, specifying a binomial distribution, a logit link function and a scale parameter set to the deviance divided by the residual degrees of freedom (using iterated, reweighted least-squares optimization of the deviance).

3. Results

3.1. General

A total of 2033 5-s intervals from 18 loadings were used for modelling, after excluding 461 intervals due to poor lighting. There were between 16 and 426 5-s intervals per loading. Seventy-one percent of the intervals (15 loadings) were coded by MA and the remaining (3 loadings) by JY. The median study time per loading used in the analysis was 39.4 (minimum 16.1, maximum 114) min. In total, 2476 pigs were loaded, with 49 to 258 pigs per loading. The number of pigs within 2 m in front of the TD (the lot) varied constantly depending on TD and pig movements, and some pigs were never part of the lot. Occasionally, pigs returned from the trailer back into the loading area and could then enter the lot. The average lot size in an interval varied between loadings from 1.8 to 5.2 (median 2.2). In half of the loadings, the pigs had been presorted by farm staff prior to loading, due to split-marketing. The pigs had been fasted for 0 to 11 (median 6) h. Thirteen TDs used both driving board and rattle paddle, and five used driving board only. No other tools were used. Descriptive statistics of pig behaviours and TD actions per loading are presented in Table 2. The most common TD action was active visual interaction and the most common pig behaviour was walking; the variation between loadings was considerable.

The percentages of intervals with one or more records of composite variables are shown in Table 3. The recorded overall occurrence varied from 25% of intervals for moderately-strongly negative TD action to 69% for pig flow. There was one loading with no stress related pig behaviour at all and five loadings with no moderately-strongly negative TD action. Farm staff present in the loading area (observed in the same or two preceding intervals) was recorded in 3.0% of the intervals and two loadings. The distribution of intervals across different levels of composite variables and independent variables is shown in Supplementary Table 9.

3.2. Correlations

Spearman rank correlations between composite variables are shown

Table 2
Mean, standard deviation and minimum and maximum number of transport driver actions and pig behaviours[a] in the pig lot[b] per loading during on-farm truck loading of Swedish finishing pigs ($n = 18$).

Subject	Variable	Mean	SD	Minimum	Maximum
Transport driver[a]	Paddle hard pig still	5.2	12	0	41
	Paddle hard pig walk vehicle	3.9	10	0	34
	Paddle hard pig walk other	0.72	2.8	0	12
	Board hard pig still	9.9	29	0	119
	Board hard pig walk vehicle	3.6	11	0	45
	Board hard pig walk other	1.3	4.2	0	18
	Hand hard pig still	6.1	15	0	60
	Hand hard pig walk vehicle	1.9	5.3	0	19
	Hand hard pig walk other	0.22	0.94	0	4
	Knee or foot	3.6		0	17
	Loud noise	14		0	205
	Paddle loose pig still	15	25	0	79
	Paddle loose pig walk vehicle	14	18	0	50
	Paddle loose pig walk other	2.1	2.8	0	8
	Board loose pig still	5.6	6.8	0	28
	Board loose pig walk vehicle	6.0	6.3	0	22
	Board loose pig walk other	2.8	3.6	0	15
	Hand loose pig still	8.1	10	0	27
	Hand loose pig walk vehicle	6.8	11	0	43
	Hand loose pig walk other	0.72	1.6	0	6
	Soft voice	17	18	0	63
	Visual active	27	45	1	170
	Visual passive	20	21	0	72
Pig lot[b]	Running	4.6	13	0	54
	Squealing	12	16	0	65
	Attentive	15	44	0	183
	Freezing	16	31	0	126
	Slipping	8.6	19	0	76
	Falling	0	–	0	0
	Crowding	18	29	0	120
	Stopping	11	12	1	39
	Turning away	10	17	0	69
	Backing	17	19	1	75
	Walking	92	68	18	253
	Turning to trailer	18	21	1	73
	Relaxed	42	39	2	139

[a] Actions and behaviours described in Supplementary Table 1.
[b] Pigs within 2 m in a half-circle in front of the transport driver.

Table 3
Percentages of 5-s intervals with one or more records of composite variables expressing transport driver (TD) actions and pig behaviours[a] in a pig lot[b], and the number of recordings per loading of the same variables, during on-farm truck loading of Swedish finishing pigs for slaughter transport; overall mean (n = 2033).

Composite variable	Percentage of intervals	Number per loading	
		Mean	SD
Moderately-strongly negative TD action	24.5	0.288	0.397
Mildly negative TD action	30.1	0.520	0.398
Any negative TD action	50.3	0.807	0.424
Positive TD action	50.1	0.873	0.569
Stress related pig behaviour	37.5	0.477	0.442
Disrupted pig flow	27.6	0.339	0.162
Pig flow	69.0	1.12	0.315
Relaxed pig behaviour	31.4	0.378	0.192

[a] Actions, behaviours and composite variables explained in Supplementary Table 1.
[b] Pigs within 2 m in a half-circle in front of the transport driver.

in Table 4. Moderately-strongly negative TD action was positively associated with stress related pig behaviour at both the interval and loading levels (ρ=0.54 and 0.87, respectively; $p \leq 0.001$). Moderately-strongly negative action was strongly positively correlated with both flow and disrupted flow at the loading level (ρ=0.73–0.75; $p \leq 0.0001$), but not at the interval level. Relaxed pig behaviour was positively correlated to both flow and disrupted flow, but only at the loading level (ρ=0.85 and 0.68, respectively; $p \leq 0.01$). Stress related behaviour was strongly associated with flow and flow at the loading level (in both cases ρ=0.85; $p \leq 0.001$), but only weakly at the interval level (ρ=0.06–0.19; $p \leq 0.05$). There were weak but statistically significant negative associations between positive and negative TD actions in the same 5-s interval (ρ=−0.18–−0.36; $p \leq 0.0001$).

3.3. Models

Final model estimates of the studied predictors are presented in Table 5 and the complete models of composite variables are given in Supplementary Tables 2–8. In most models, the odds of one or more of the modelled TD actions and pig behaviours increased significantly when the studied predictors occurred in the same interval and/or a preceding interval. Thus, the probability of stress related pig behaviour increased substantially if any negative TD action occurred in the same interval (OR=4.1–5.4; $p<0.0001$) and markedly even if a moderately-strongly negative TD action was recorded in the preceding interval (OR=2.0; $p = 0.0005$). Disrupted flow was associated with any negative TD action in the same interval (OR=1.6; $p = 0.0002$). Conversely, the probability of moderately-strongly or any negative TD action increased markedly if stress related pig behaviour occurred in the same interval (OR=3.6–5.4; $p<0.0001$) or in one of the two preceding intervals (OR=1.9–3.4; $p \leq 0.0001$). The association of any negative TD action with disrupted flow was less clear but still significant when disrupted flow occurred in the preceding interval (lag-1) (OR=1.3; $p = 0.046$). The probability of relaxed pig behaviour increased if positive TD action was recorded in the same interval (OR=1.9; $p<0.0001$) or in the preceding interval (lag-1) (OR=1.3; $p = 0.014$). Moderately-strongly negative TD action had a slightly decreasing effect on disrupted flow when recorded two intervals back (OR=0.69; $p = 0.048$).

The risk of stress related pig behaviour appeared to be lowest at a TD

Table 5
Estimates from models of composite variables expressing transport driver (TD) actions and pig behaviours[a] in a pig lot[b] during a 5-s interval during on-farm truck loading of Swedish finishing pigs for slaughter transport, showing effects of studied predictors in the same 5-s and the two preceding 5-s intervals (n = 2033).

dependant variable	studied predictor	lag[c]	odds ratio	stand. error	p
Stress related pig behaviour	Moderately-strongly negative TD action	0	5.43	0.916	<0.0001
		−1	2.01	0.405	0.0005
		−2	1.18	0.238	0.42
Stress related pig behaviour	Any negative TD action	0	4.11	0.580	<0.0001
		−1	1.40	0.191	0.013
		−2	1.36	0.181	0.022
Disrupted pig flow	Moderately-strongly negative TD action	0	1.28	0.209	0.13
		−1	0.956	0.187	0.82
		−2	0.685	0.131	0.048
Disrupted pig flow	Any negative TD action	0	1.63	0.211	0.0002
		−1	0.955	0.129	0.74
		−2	0.823	0.108	0.14
Relaxed pig behaviour	Positive TD action	0	1.86	0.213	<0.0001
		−1	1.32	0.145	0.014
		−2	1.21	0.133	0.086
Moderately-strongly negative TD action	Stress related pig behaviour	0	5.44	0.846	<0.0001
		−1	3.36	0.550	<0.0001
		−2	1.87	0.303	0.0001
	Disrupted pig flow	0	0.895	0.141	0.48
		−1	0.799	0.139	0.20
		−2	1.03	0.182	0.88
Any negative TD action	Stress related pig behaviour	0	3.56	0.481	<0.0001
		−1	2.91	0.446	<0.0001
		−2	2.14	0.327	<0.0001
	Disrupted pig flow	0	1.28	0.160	0.046
		−1	1.25	0.176	0.12
		−2	1.12	0.168	0.44

[a] Actions, behaviours and composite variables explained in Supplementary Table 1.
[b] Pigs within 2 m in a half-circle in front of the transport driver.
[c] Lag 0=same interval; lag −1=preceding interval; lag −2=two intervals back.

Table 4
Rank correlation matrix of composite variables expressing transport driver actions and pig behaviours[a] in a pig lot[b] during on-farm truck loading of Swedish finishing pigs for slaughter transport; at the level of 5-s intervals (lower left cells; n = 2033) and loadings (upper right cells; n = 18); Spearman rho and statistical significance[c].

	Moderately-strongly negative action	Mildly negative action	Any negative action	Positive action	Stress related behaviour	Disrupted pig flow	Pig flow	Relaxed behaviour
Moderately-strongly negative action	1	0.13	0.81***	0.32	0.87***	0.75***	0.73***	0.38
Mildly negative action	−0.17***	1	0.58*	0.41	0.23	0.29	0.36	0.37
Any negative action	0.60***	0.59***	1	0.36	0.82***	0.70**	0.78***	0.53*
Positive action	−0.20***	−0.18***	−0.36***	1	0.47*	0.72***	0.70**	0.70***
Stress related behaviour	0.54***	−0.03	0.42***	−0.19***	1	0.85***	0.85***	0.56*
Disrupted pig flow	0.09***	0.05*	0.12***	0.06**	0.19***	1	0.85***	0.68**
Pig flow	0.03	0.09***	0.10***	0.14***	0.06*	0.20***	1	0.85***
Relaxed behaviour	−0.18***	0.03	−0.14***	0.20***	−0.22***	−0.02	−0.04	1

[a] Actions, behaviours and composite variables explained in Supplementary Table 1.
[b] Pigs within 2 m in a half-circle in front of the transport driver.
[c] Significant at * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$.

age of 27–29 years, and dramatically increased at an age of more than 40 years (Supplementary Tables 2 and 3). The risks of stress related pig behaviour and negative TD actions also varied greatly between hauliers (Supplementary Tables 1, 2, 7 and 8). More than 3 pigs within 2 m in front of the TD, compared with fewer pigs, seemed to increase the risks of stress related behaviour and disrupted flow (Supplementary Tables 2–5). The risk of disrupted flow was higher if the pigs had been sorted before loading, and the risk decreased with an increasing ramp width (Supplementary Table 5). The probabilities of stress related behaviour, disrupted flow and relaxed pig behaviour decreased markedly when farm staff was present in the loading area (Supplementary Tables 2–6).

The intraclass correlation coefficient at the loading level was 0.23 in the empty two-level model of stress related pig behaviour, 0.067 for disrupted flow, 0.50 for moderately-strongly negative TD action, 0.30 for any negative TD action and 0.094 for relaxed pig behaviour. This indicates that moderately-strongly negative TD actions were substantially correlated within the same loading, while the other dependant variables were only slightly correlated within loading. No random estimates of loading were obtained in the final models.

There was no severe overdispersion (Pearson χ^2/df = 1.02–1.34), but some Pearson residuals were larger than 2 (absolute values) and the Pearson χ^2 test indicated that the models in most cases did not fit the data well (p = 0.0004–0.066). Despite this, generalized linear models produced almost unchanged estimates compared with the models presented. The area under the Receiver Operating Characteristic curve was between 0.66 and 0.90, which indicated a good to excellent model fit and discriminative ability.

4. Discussion

To our knowledge, this is the first scientific study of behavioural interactions between TDs and pigs during loading for slaughter transport. In line with our hypotheses, we found handling of a negative nature to be associated with stress related pig behaviour and that the relationship was reciprocal, and handling of a positive nature associated with relaxed pig behaviour. Although only 18 TDs participated in the study, they constituted about 15% of the total number of pig TDs operating in Sweden.

The most common composite variable was pig flow, which included walking, and was seen in 69% of the intervals. The second most common composite pig variable was stress related behaviour, which included crowding, freezing, attentive behaviour and squealing, and was seen in 38% of the intervals. Relaxed pig behaviour, which included a relaxed body posture and head below shoulders, was observed in 31% of the intervals. Relaxed pig behaviour was defined based on body posture with head below shoulder height, and could also have included explorative behaviour with the snout close to the ground, which is a highly motivated behaviour in pigs (Studnitz et al., 2003). The relatively high occurrence of stress related behaviours indicates that transport loading is a stressful situation for pigs. For practical reasons, we were not able to carry out physiological measurements of, for example, heart rate, cortisol levels or body temperature, which otherwise might have increased the understanding of how pigs perceived the loading. This might be a task for future research.

The risk of stress related pig behaviour was significantly increased when negative TD actions occurred one 5-s interval back. Moreover, the risk of negative TD actions was significantly and markedly increased when stress related pig behaviour was recorded one or two 5-s intervals back. In contrast, the probability of relaxed pig behaviour increased when positive TD actions occurred one 5-s interval back. These results provide evidence of possible reciprocal relationships between TD actions and pig behaviour. Previous research has examined long-term relationships between stockpersons and their animals (Hemsworth et al., 2018), and the results in the present study is the first evidence of a short-term reciprocal relationships between TD actions and pig behaviour. Humans under acute stress perform worse at cognitively complex tasks and try to avoid them (Bogdanov et al., 2021), which might mean that TDs' make worse decisions and act negatively towards the pigs under stress, also when it is the pigs themselves who inflict the stress. The existing time constraints for loading (Wilhelmsson et al., 2021) likely increase the risk of TDs trying to move pigs quickly by applying more forceful actions, which pose a risk of a vicious cycle arising. However, these results and the high percentage of intervals with negative TD actions suggest an opportunity to improve pig welfare by training TDs to decrease their negative and increase their positive handling actions, as demonstrated by Hemsworth et al. (2018). Training of animal caretakers has previously been emphasized as an essential means of avoiding stress in pigs (Costa, 2009). Training may also reduce physical work load and affect work efficiency (Wilhelmsson et al., 2022) improving the animals' welfare and human wellbeing simultaneously.

As expected, there was a positive correlation between moderately-strongly negative TD action and stress related pig behaviour and disrupted flow. The association was somewhat weaker at the interval level than at the loading level, suggesting that these behaviours did not always occur in close sequence. More surprisingly, moderately-strongly negative TD action was also positively correlated with pig flow at the loading level, which might reflect that the pigs respond to handling of a negative nature by turning and moving away from the TD towards the trailer, although with a higher stress level.

In general, conditions during loading vary greatly. Factors related to housing, herd management, loading area and truck design and weather, as well as TD attitudes and working routines, may all influence handling actions and pig welfare (Goumon and Faucitano, 2017). In an observational study like this, it is not possible to account for all these factors. The limited number of TDs and loadings observed also reduce the opportunities for analytical control of confounding factors. We chose to offer a limited number of TD characteristics and environmental descriptors for model inclusion, and found large variations in environmental factors, including different loading area features. As in all observational data analysis, a different set of variables could have produced different model estimates for the studied predictors. The design of the loading area in particular can influence pig welfare during loading (Berry et al., 2012), but is difficult to characterize by a few numerical variables.

Observed effects of TD and environmental factors, in addition to the studied predictors, should hence be interpreted with caution, but some strong and consistent trends could be discerned. The risks of stress related pig behaviour and negative TD actions varied greatly between hauliers and a relatively high TD age compared with a moderately low age, seemed to increase the risk of stress related pig behaviour. Several pigs within 2 m in front of the TD, compared with one or two pigs, also increased the risk of stress related behaviour and disrupted flow in the pig lot. This was possibly because the TD could not reach the pigs blocking in the front of the group, leading to an increased TD effort and actions of a negative nature towards the pigs within reach, with increased stress in the whole pig lot. Lewis and McGlone (2007) found that a group size of more than five to six pigs increased handling difficulties and Dalla Costa et al. (2019) found that moving pigs in groups of five improved animal welfare. In this study, to facilitate behavioural observations and statistical analysis, we focused on the number of pigs within 2 m in front of the TD. However, this did not necessarily reflect the total number of pigs between the TD and the trailer. Naturally, humans can interact with pigs without physical contact, even at large distances, for example by visual or auditory signals. It is likely that pigs, further away than 2 m, may have been affected by for example loud noise or a soft voice from the TD. Lot size varied constantly depending on TD, farm staff working routines, and pig movements. To facilitate behavioural observations and statistical analysis, we limited the lot and behavioural observations to pigs that were within a half-circle with a radius of 2 m in front of the TD, and behaviours in pigs outside the lot were disregarded. Pre-sorting, which is one of the farm working routines, seemed to increase the risk of disrupted pig flow. Pre-sorting probably leads to more mixing of pigs from different pens, which is known to increase the risk of pigs fighting (Driessen et al., 2020), although no agonistic behaviour was observed in the present study. It is known that pigs of the same weight investigate each other for a while after mixing, before they start to fight (Jensen and Yngvesson, 1998), which could be one underlying cause of this increase in disrupted pig flow.

According to intraclass correlation coefficients for the empty model, moderately-strongly negative TD actions were substantially correlated within the same loading. This correlation almost disappeared in the final model, which indicates that the fixed effects (stress related and disrupted flow, recorder, haulier, hour of day and ramp length) explained most of the correlation within loading. It suggests that the main explanation for the correlation between observations within a loading was not TD characteristics or handling strategy, but rather other loading conditions.

Wide variation between farms and loadings likely reduces TD opportunities to predict and control the situation and maintain good working routines. Anneberg and Sandøe (2019) reported that a negative working environment is a risk factor for poor animal welfare on Danish pig farms. In this project, TDs reported that perceived difficulties in loading pigs contributed to knee discomfort associated with pressing their knees against the driving board (Wilhelmsson et al., 2021).

The pig industry and the conditions for pig handling during loading for slaughter transport varies between countries. For example, farm and herd size differs, and the type and size of vehicles, as well as the developments introduced in the design of the loading area and training of TDs. Regardless of this, the biological mechanisms that govern human-pig interactions are likely to be essentially the same. We therefore believe that the results of this study are largely applicable to loadings in countries other than Sweden.

5. Conclusion

We conclude that handling of a negative nature by transport drivers when loading pigs is associated with stress related pig behaviour, while handling of a positive nature is associated with relaxed pig behaviour. The results of this study suggest a reciprocal relationship between TD actions and pig behaviour and that this bidirectional feed-back loop provides an opportunity to modify TD actions through training to improve pig welfare.

CRediT authorship contribution statement

Sofia Wilhelmsson: Data curation, Investigation, Methodology, Project administration, Resources, Writing – original draft, Writing – review & editing. **Maria Andersson:** Conceptualization, Funding acquisition, Writing – review & editing. **Paul H. Hemsworth:** Conceptualization, Methodology, Writing – review & editing. **Jenny Yngvesson:** Conceptualization, Writing – review & editing. **Jan Hultgren:** Data curation, Formal analysis, Software, Supervision, Validation, Visualization, Writing – review & editing.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.livsci.2022.105150.

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