

# The relationship between cattle personality traits and precision technology-based measures of feeding behavior, activity, and production: A narrative review

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## Abstract

The personality traits in cattle have been traditionally measured in highly controlled experimental settings. Precision technologies can measure a myriad of variables continuously, including feeding behavior, activity, and production measures. The utilization of precision technologies grants the opportunity to explore behavioral patterns that may be related to animal personality traits in a natural setting. This study's aim was to investigate the relationship between the behavioral responses of the individual from personality tests and the different measures from precision technologies. In this narrative review, we found that growth, intake, activity, and milk production all have variable relationships with certain personalities and behaviors that are identified from standardized tests. These relationships between personality traits and the behaviors measured by precision technology indicate that stable differences among individuals can be measured and identified in natural settings.

**Keywords:** temperament, coping styles, ruminants, animal welfare

## Introduction

Animal personality can be defined as a multitude of behavioral responses (i.e. personality traits) that are consistent across time and contexts (Kaiser and Müller, 2021). These personality traits are measured through behavioral responses to different environmental stimuli. Introduction to a new object, person, or environment would elicit behavioral responses that differ across individuals, and these can be used to characterize their personality traits. Fearfulness, boldness, and aggressiveness are often some of the personality trait spectrums that are observed through responses to stressor events (Lecorps et al., 2018). Highly excitable or fearful animals, especially in intensive production systems and with high level of handling, may have detrimental impacts to animal production.

Cattle behavior relies solely on their perception that helps them to communicate with the environment that may prove necessary to survival (Adamczyk et al., 2013). The introduction of novelty, whether a novel object, person, or environment elicits fear response in cattle (Forkman et al., 2007). Social isolation also elicits behavioral responses from cattle that may indicate fear or nervousness (Schrader and Müller, 2005). There is evidence in the literature that a relationship between fear or other undesirable traits have a relationship with production in cattle. The existence of the relation between fear and productivity in commercial reared cattle may provide farmers with the opportunity to reduce fear to improve cow productivity (Breuer et al., 2000).

Cattle production has had technological progress in all parts of farming including but not limited to genetics, nutrition, reproduction, disease, and management. Cattle are a part of production systems that includes a myriad of technology for all aspects of farming, and this technology can be useful in furthering production and behavioral measures that are beneficial to the producer. Consequently, it is vital to be able to identify individual behavioral differences to mitigate the negative short term and long-term effects on the animal.

Precision livestock farming (PLF) or precision dairy technology (PDT) is defined as the utilization of real time technology that manages animals as well as collects individual information and/or data on farm (Costa et al., 2021). Real time technology has the opportunity to increase farm efficiency, or to manage production parameters and the behaviors of the individual (Cantor and Costa, 2022). General on-farm precision technology may include automated calf feeding systems (AFS), automated milking systems (AMS), leg pedometers, and smart collars. Precision technology can measure a myriad of parameters, namely step count, estrus detection, daily milk yield, milk conductivity, average daily gains, body measurements, and temperature. Behavioral changes or any deviation from normal behavior will be identified by the precision technology and alerts the producer. Changes in individual behavior could be linked to estrus, calving, or even illness. Therefore, identification of behavioral changes using precision technology will help producers to make more timely decisions and improve their welfare and productivity on farm.

Behaviors and measures from precision technology may prove to have a relationship with personality traits based on daily behavioral patterns. These individual differences have the potential to be measured and identified early in life and should therefore be explored. There has been no review to our knowledge on the available literature that identifies precision technologies and how their outputs relate to personality traits. The main aim of this narrative review is to explore the relationship between behavioral responses of the individual from personality tests and the different measures from precision technologies. This review investigates the literature available on growth, feed intake and feeding behavior, activity, and milk production output measures from precision technologies and their relationships to individual personality traits in cattle.

A literature search from since the year 2000 was conducted on the databases of Google Scholar and Web of Science utilizing the following search words: precision dairy technology, precision livestock farming, activity monitors AND dairy, beef, bull steer, heifer, ruminants, cattle, calf AND personality, personality traits, coping styles, temperament, behavioral patterns, behavioral syndrome AND individual differences, individual variation, behavioral type, accelerometer, sensor. A total of 459 articles resulted from the literature search on Web of Science and were screened to ensure the articles contained personality or behavioral tests that were compared to variables resulting from precision technologies. The articles from the search on Google Scholar were screened utilizing the same criteria for Web of Science. There were 22 articles retained after screening. Additional articles were included following examination of the reference lists of screened articles (8 articles), recently accepted or in press articles from our own research group (1 article), and articles in preparation from our research group (1 article). Thus, the review included a total of 32 articles.

## **Growth**

One general on-farm precision technology that can be utilized to measure growth in cattle is the scale incorporated with AFS. Measures from the AFS have been related to personality traits found in novel tests. Neave et al. (2019) identified five traits utilizing novelty tests and early life characteristics: low vitality, fearful, strong drinker, slow learner, and exploratory-active. Calves that scored high for exploratory-active had a higher pre-weaning, weaning, and total ADG that resulted in higher final BW. This study also found that slow learning calves (to drink from the feeder) had a tendency for reduced preweaning ADG, and low vitality calves had reduced preweaning ADG. Neave et al. (2018) reported similar results between automated milk feeding systems and personality traits from standardized personality tests. They found exploratory-active calves had greater overall average daily gains, interactive calves had tendencies for reduced ADG during the full-milk period, and vocal-inactive calves had tendencies for greater ADG during the milk-reduction period. A more recent study also examined the relationship between measures from automated milk feeding systems and personality tests in group housed Holstein calves (Woodrum Setser et al., 2022). Together these

studies provide the first evidence of an association between personality traits from standardized personality tests and ADG measures from calves fed using automated milk feeding systems. Further research should investigate the ability of such variables in early life to predict productivity and potentially tailor individualized management for the animals.

### **Feed intake and feeding behavior**

Another variable that can be measured utilizing precision technologies on farm is milk and/or solid feed intake. In addition to growth, AFS can also measure intake for individual calves. Neave et al. (2018) reported that exploratory-active calves consumed more grain in pre-weaning, weaning, and post-weaning periods. In addition, calves that were slow to learn to use the automated feeder had reduced preweaning and overall dry matter intake, driven primarily by reduced milk intake, while fearful calves had no associations with feed intake (Neave et al., 2019). Whalin et al. (2022) also explored the relationship between automated milk feeders and personality traits from personality tests. Calves that were more playful/exploratory consumed more milk per day in preweaning and had higher feed intake per day. In contrast, vocal/inactive calves had lower preweaning milk intakes and lower concentrate intakes over the experimental period. Lastly, interactive calves had lower preweaning and weaning concentrate intakes. Another study identified fearful, bold, and active traits from standardized personality tests and related it to intake measures from the automated milk feeding system (Woodrum Setser et al., *in preparation*). Fearful calves had a significant positive association with milk intake, active calves had significant negative associations with milk intake, and bold calves had no association with intake.

In adult dairy cattle milked in an automated milking system (AMS) and fed from automated feed bins, cows that were more alert-curious consumed more of a partial mixed ration while cows that were more fearful of a novel human were less likely to consume their concentrate allowance in the AMS, resulting in less total DMI and more variability in intake (Schwanke et al., 2022). Several studies in beef cattle have also reported reduced feed intake at the feedlot in individuals with greater agitation score and flight speed in a chute test (Cafe et al., 2011; Elzo et al., 2009), and high reactivity when isolated in a pen with a handler (Black et al., 2013). The consumption of feed necessarily involves feeding behavior patterns that are also variable among individual. Some of the above-mentioned studies reported some relationships between personality traits and measures of feeding behavior patterns, such as visits to the milk feeder (Neave et al., 2018, 2019; Whalin et al., 2022) or AMS visits resulting in concentrate delivery (Schwanke et al., 2022). Additionally, grazing time in pastured dairy cattle (measured using an ear-based accelerometer) was greater in more calm-investigative individuals (Neave et al., 2022). A focus on these feeding behavior patterns can be insightful. A recent study used the behavioral patterns of AFS use in dairy calves to characterize personality, where consistent individual differences in meal frequency and drinking speed formed a personality trait that predicted weight gain (Carslake et al., 2022). Future research should be conducted to further explore how intake and feeding behaviors of cattle can be predicted utilizing measures from precision technologies and tests that identify the personality of the animal.

### **Activity**

Activity of individuals can be measured utilizing precision technologies such as tri-axial accelerometers and can be related to personality traits identified from personality tests. In a study of pastured dairy cattle, cows that were more fearful of humans had reduced lying time (measured using leg-based accelerometers) (Neave et al., 2022). Another study identified three personality traits from standardized personality tests (neophobia, vocalization, and boldness) and related it to activity measures from tri-axial accelerometers in dairy cows (MacKay et al., 2014). Neophobic cows exhibited more lying bouts and greater variation in

average duration of lying bouts. Bold cows were less variable in their average lying bout duration, and cows more tolerant of human approach had fewer lying bouts per day and shorter average standing bout duration. Research in beef cattle have related differences in flight speed and chute scores to activity measures from tri-axial accelerometers (MacKay et al., 2013). The high flight speed response of individuals resulted in more activity in the home pen and more variability in step count. This study also found that steers that had high displacement index had less daily lying time and long average standing bout durations. Bruno et al. (2018) utilized an ear tag accelerometer and identified behavioral characteristics of beef steers from chute exit velocity and an objective chute score (measuring variability in weight recordings). Steers that exhibited low objective chute score tended to have higher daily activity counts than high objective chute score steers and steers that displayed fast exit velocities had higher activity counts than steers that had slower exit velocities.

In individually housed crossbred calves, standardized personality tests identified fearful, inactive, and bold traits and revealed a relationship with activity from tri-axial accelerometers (Michalski et al., 2023). The score for the trait inactive from standardized personality tests had negative associations with mean motion index and mean steps from leg accelerometers. No other personality traits had associations with activity. Lastly, group housed Holstein calves were classified as fearful, bold, or active from standardized personality tests and compared to tri-axial accelerometer activity (Woodrum Setser et al., in preparation). Fearful calves had significant positive associations with steps and activity index. Bold calves had significant positive associations with steps and active calves had no associations with activity. Together these studies demonstrate measures of personality from standardized tests are associated with activity in the home environment. Recent work has explored solely using precision technologies to characterize personality, without the use of standardized personality tests; location sensors determined consistent individual variation in movement and space use, demonstrating active and exploratory personality traits (Occhiuto et al., 2022). Thus, there is opportunity to identify characteristic personalities using precision technologies from day-to-day recordings of activity, and further research should explore how differences in activity relate to individual personalities.

## **Milk production**

Milk production of mature cattle can be measured using automated milking systems, or associated software. The information from this precision technology can be used in comparison against personality and behavioral tests to further explore whether producers can make timely decisions based on the results. Some of the first studies exploring this relationship found that milk yield was lower in cows that were more fearful or reactive toward humans in a standardized test (Hemsworth et al., 2000; Breuer et al., 2000), but more recent studies have found mixed results regarding the human-animal relationship and milk yield. Greater avoidance distance (i.e. cows more fearful of humans) was positively correlated with milk flow rates during weeks 1 and 6 of lactation and milk yields during week 6 of lactation (Sutherland and Dowling, 2014), while Sutherland et al. (2012) and Neave et al. (2022) did not observe any relationships between behavioral responses in a series of novel human tests and milk yield. Behavioral responses to a novel object test have also produced contrasting findings, with one study demonstrating increased milk yield in pastured dairy cows that were more curious/investigative (Neave et al., 2022) and two others showing no effect in indoor housed dairy cows (Hedlund and Løvlie, 2015; Marçal-Pedroza et al., 2020). However one of these studies did find a relationship between milk yield and a social isolation test, where more fearful (vocal) cows had lower milk yield (Hedlund and Løvlie, 2015). Recent work has used data from milking robots that are growing in popularity among producers. Schwanke et al. (2022) utilized personality tests to identify active, social, and alert-curious cattle within the novel environment and object tests, and active-vocal and fearful cattle in the novel person test. Cows who were more active in the novel arena and object tests had lower milk production at enrollment. Overall, these studies indicate the value of characterizing personality traits of dairy cattle to understand

variability in milk production; future research should explore whether personality traits throughout life can predict milk production in the mature cow using precision technologies.

## Conclusions

Emerging research indicates that personality traits (consistent individual differences in behavior) of cattle have relationships with production, activity, and feeding behavior. Cattle behavior can be measured utilizing standardized behavioral tests, referred to as personality tests. Further, precision technologies exist that can compute activity, production, and feeding behavior measures. This limited literature review reveals there is a clear relationship between the measures from these precision technologies and personality of individual animals. This relationship can be utilized to identify individuals that require greater attention from the producer, and those that are performing well, allowing for more timely decisions (such as animal selection) for the future of the farm. Future research should explore how precision technologies can characterize animal personalities that predict individual variability in performance on commercial operations.

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