Look at that!—The effect pictures have on consumer preferences for in ovo gender determination as an alternative to culling male chicks[1]

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ABSTRACT Gender determination in incubated eggs (in ovo) has the potential to substitute the highly discussed practice of culling male layer chicks. The aim of this study was to investigate the effect pictures have on peoples' preferences toward in ovo sexing at different stages of embryonic development and chick culling. For this purpose, an online survey was conducted with a representative sample of 482 respondents in Germany. A within-subject design with 2 choice experiments was used to investigate the influence pictures have on respondents' preferences and willingness to pay. The first-choice experiment contained plain text only; the second contained also pictures of a chick or the incubated eggs at the corresponding stages of development. Findings reveal that in ovo gender determination at each proposed day of incubation (d1, d4, and d9) was preferred to chick culling. In ovo screening on d1 and d4 was significantly preferred to d9. This preference for early gender determination increased significantly as a consequence to the provision of pictures. Results furthermore reveal that a high error rate of gender determination or the lack of a meaningful utilization of incubated eggs can decrease approval for in ovo gender determination to an extent, where no positive willingness to pay remains. Findings of this study are useful for stakeholders in poultry production when considering the implementation of in ovo gender determination as a morally admissible substitute to chick culling.

Key words: chick, choice experiment, gender determination, in ovo, picture

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INTRODUCTION

Pictures say more than words—besides providing information, they can evoke associations and feelings in the wink of an eye. The "picture superiority effect" describes the fact that pictures are remembered longer and better than text (Childers and Houston, 1984). Furthermore, pictures are considered to be more credible (Graber, 2016) and to trigger stronger emotions than written words, especially when they have an unpleasant content (Hajcak and Olvet, 2008).

In an environment of mass media, pictures are readily available and fast moving through digital channels, which makes them drivers of societal debates. This applies especially for the agricultural context, where mass media has become an important source of information (Mayfield et al., 2007; Wunderlich and Gatto, 2015). Debates about farm animal welfare have been shown to be strongly influenced by pictures in the last couple of years. One example is the debate about cage housing for layer hens, which was driven by NGOs who provided pictures and videos of confined hens in cages (Busch and Spiller, 2018). The debate led to the ban of the husbandry system in 2012 in the EU (European Commission, 1999).

A topic which is currently present in the media and debated in a number of western societies, for example the Netherlands and Germany (Woelders et al., 2007; German Federal Ministry of Food and Agriculture, 2018), is the culling of millions of male layer chicks. These do not serve an economic purpose and are therefore culled after hatching. The topic is causing public resonance, and also the awareness among stakeholders in egg production rose (United Egg Producers, 2016; Unilever, 2018). Alternatives such as dual-use poultry

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production and gender determination in incubated eggs (in ovo) came under consideration (Krautwald-Junghanns et al., 2018; Murawska et al., 2019). In ovo gender determination is the technical alternative which has the potential to substitute chick culling at an industrial scale. The technology enables detecting eggs with male chicken embryos during incubation in hatcheries. Eggs with male embryos are then removed from the incubator and can be used as animal feed or in the chemical industry under limitations (European Commission, 2009). (In accordance with Regulation (EC) 1069/2009 (European Commission, 2009); incubated eggs are classified as so-called category 3 material. This regulation furthermore determines the potential use of this material.)

Two in ovo technologies are expected to reach market maturity in the near future. They are executed at different stages of embryonic development. The first is a method determining the gender on d4 of incubation by a spectroscopic analysis of extraembryonic blood vessels (Galli et al., 2017). The second method analyzes the estradiol content of allantoic fluid on d9 of incubation (Weissmann et al., 2013). A third possibility is currently under discussion, which is aiming to analyze the gender through magnetic resonance. It might offer the possibility to sex eggs within the first day of incubation, but it is currently not clear on which level of precision or when it will reach market maturity (TUM Press statement, 2018). A technology for gender determination at d14 has already been developed (Göhler et al., 2017). However, currently it has not been pursued further as the chicken embryo is already at an advanced stage of development.

There is evidence that the societal acceptance for in ovo screening will largely depend on the point of time during embryonic development, when screening is performed (Leenstra et al., 2011; Brunijs et al., 2015). It can be assumed that the moral value given to the chicken embryo increases with embryonic development (for a discussion on moral status of embryos, see Strong, 1997). To be a meaningful alternative to the current practice, destruction of embryos should be performed at an early stage of development, before conscious pain perception is possible. It is still under discussion, when this is the case in chicken embryos. The possibility to perceive pain is assumed to develop stepwise from d7 of incubation on until the brain is fully developed at d13 (Aleksandrowicz and Herr, 2015). The degree to which pain is experienced at this stage of development is uncertain (Eide and Glover, 1995; Bjørnstad et al., 2015). Mellor and Diesch (2007) argue that chicks are unconscious until at least d17. In contrast the Guidelines of the American Veterinary Association (Leary et al., 2013) presume consciousness at 50% of incubation time, therefore from d10.5 on. Based on the aforementioned information, it can be assumed that pictures of developing chicken embryos, which circulate in the media and are used by interest groups in a targeted manner, as in the case of cage housing of layer hens, might hold a considerable potential for social resonance. As a result, concerns about animal welfare could arise and the public opinion on in ovo gender determination could be sustainably influenced.

The influence of pictures on consumer attitudes and product choices has been analyzed in former studies. Hollands et al. (2011) found that communicating "images of energy-dense snack foods paired with aversive images of the potential health consequences of unhealthy eating" significantly decreased respondents' choice probability for corresponding snacks, as a consequence of an adverse effect on consumer attitudes toward these products. Germain et al. (2010) found that brand elements significantly increased adolescents' appeal for cigarette packs, whereas increasing the size of images with health warnings had the opposite effect. Pearl et al. (2012) analyzed the impact of positive or stigmatizing pictures on respondents' attitudes toward obese persons. The authors found that the manner in which the person was portrayed in the pictures had an influence on the participants' desire for social distance toward the depicted person, which stresses the influence pictures have on social attitudes. A limited body of literature addresses the effect of images on societal or on consumers' perceptions of agricultural production systems. Schröder and McEachern (2004) found that pictures of housing systems on egg cartons from cage housing and pork packaging decreased consumer's willingness to buy these products. Rumble and Buck (2013) compared the influence of pictures of conventional and traditional housing systems on consumer's perceptions of these systems and found that pictures triggered emotions and a logical way of thinking about the advantages and disadvantages of housing systems. Busch et al. (2015) confronted consumers with pictures of intensive broiler fattening barns and found that this production system as a consequence was evaluated as very negative. In another study of Busch et al. (2017), participants were asked to evaluate different pictures of one and the same pig pen, which were taken in different perspectives. Students of agricultural sciences did not evaluate the pictures differently, whereas nonagricultural students showed to be sensitive to the variation of the perspective. Wille et al. (2017) analyzed whether the provision of pictures or text influences consumers' perception about pig transports diversely. Möstl and Hamm (2016) as well as Gauly et al. (2017) found that showing webcam pictures of pig production systems to respondents results in negative perceptions of consumers about the way pigs are reared.

Although the impacts of pictures were analyzed experimentally in different areas, as far as we are aware, the use of pictures in discrete-choice experiments (**DCE**) was very limited. Rizzi et al. (2012) investigated the impact of written descriptions and images of traffic on the respondents' evaluation of travel time savings in a choice experiment; the authors found a statistically significant difference between the treatment with and without pictures. A similar approach was used by Patterson et al. (2017), comparing 2 choice experiments with text-only descriptions and virtual-reality images in the context of neighborhood choice. Findings reveal that respondents were more focused in the virtual-reality setting.

Furthermore, the relevance of an exact pictorial representation of the alternative is emphasized. To the best of our knowledge, the impact of images on attitudes regarding animal welfare has not been tested before using a DCE.

The objective of this study was to investigate the effect pictures have on consumers' choice behavior regarding the context of in ovo gender determination and chick culling. (The aim of this study was to analyze the details of consumer acceptance of in ovo gender determination at different stages of embryonic development in comparison with chick culling. Therefore, other alternatives as, for example, dual-purpose chicken were not examined. For the comparison of in ovo gender determination and dual-use poultry production, please refer to Reithmayer et al. (2019).) Furthermore, consumers' attitudes and willingness to pay (**WTP**) for in ovo screening at different stages of embryonic development are analyzed. For this purpose, a DCE with 482 consumers was conducted between December 2018 and March 2019 in Germany. A within-subject design with 2 experiments was used for the purpose of this study.

To the best of our knowledge this study is the first that investigates the influence of pictures in a DCE concerning animal welfare and the context of chick culling. The study provides furthermore comprehensive insights about consumers' attitudes and acceptance of the in ovo technology. As German citizens will likely be among the first to be confronted with poultry products from systems with in ovo gender determination, the study gives valuable insights to consumer attitudes in a market, where the debate about chick culling is highly topical. Findings are beneficial for stakeholders in egg production, as well as politicians.

MATERIALS AND METHODS

Design of the Discrete-Choice Experiment

By using the stated preference approach, the DCE allow for conclusions to be drawn from previously unarticulated preferences about real-choice decisions (Louviere et al., 2000). The attribute-based measure of respondents' preferences is thereby possible through a series of hypothetical decision-making situations (List et al., 2006). These decision situations are called choice sets, each consisting of different alternatives. Participants are asked to select one of the given alternatives. Each presented alternative is characterized by predefined attributes and their associated levels. By systematically varying the attributes and their levels, the respective influence on the choice decision can be determined (Louviere et al., 2000).

The DCE utilized in this investigation presented the following decision situation to the participating consumers: based on an unlabeled design, the consumers had to choose between 2 generic alternatives A and B or could decide whether or not to use either of these alternatives (opt out). (The opt-out option can be chosen by consumers if the presented combinations of attribute levels do not meet their preferences, or if they prefer other alternatives for handling male chicks.) The opt-out alternative was included so that the choice for one of the proposed alternatives remained voluntary. A forced choice could lead to inaccuracy and inconsistency with the demand theory (Hanley et al., 2001). The attributes and their levels were chosen based on the premises of relevance and complexity of the experiment. Both were addressed by reviewing the literature and seeking expert advice.

The following 4 attributes were used to describe the alternatives in the DCE: 1) the day of gender determination, 2) the later use of incubated eggs or—for the current practice—male chicks, 3) the error rate, including incorrect gender determination and lower hatchability, and 4) extra cost of in ovo sexing compared with the current practice described as price increase per box of 10 eggs. (Boxes of 10 eggs are a common package size in Germany.) An overview of attributes and levels used in the experiment is presented in Table 1; furthermore, they are described subsequently.

The feasible days of gender determination, as derived from the literature and the current political discussion, are prospectively d4 of incubation (Galli et al., 2017) or d9 of incubation (Weissmann et al., 2013). An approach aiming for gender determination at d1 is furthermore discussed (TUM Press statement, 2018). In the DCE, the in ovo gender determination is compared with the current practice of culling male chicks at the day of hatch (d21). These 4 possibilities are defined as the levels of the first attribute.

The later use of incubated eggs depends on the preceding incubation time. Eggs can be used as pet feed, livestock fodder component, or in the chemical industry (e.g., for shampoo), whereas male chicks are currently mainly used as pet feed (European Commission, 2009). Depending on the current market situation, it might occur that male chicks or eggs would also be thrown away as waste. The 4 levels of the second attribute are defined accordingly.

In ovo gender determination can influence hatchability negatively. Furthermore, an error rate in gender determination remains. In this way, also eggs with female embryos could be sorted out by mistake, leading to an increase of incubated eggs and animals needed in layer hen production. These factors are summarized to the attribute "error rate"; its levels are defined in a range between 1 and 15%, according to the gender determination process error rate, which was found in the literature (Weissmann et al., 2013; Galli et al., 2017; Krautwald-Junghanns et al., 2018).

The price increase incurred per box of 10 fresh consumption eggs is defined following the findings of Leenstra et al. (2011) and the price observed in a German pilot project ("SELEGGT"-label of the REWE Group). Eggs from the pilot project with in ovo screened hens were sold with a premium of €0.02 per egg in comparison with the conventional product. Conducting an online survey, Leenstra et al. (2011) found positive WTP for alternatives to chick culling for the majority of respondents, ranging from the statement to be willing

Table 1. Attributes and levels of the discrete choice experiment.

Attributes	Levels
Day of gender determination	d1 |d4 |d9 |d21/chick
Usage of eggs or male chicks	waste (no use) | chemical industry | pet food | fodder
Error rate	1% | 5% | 10% | 15%
Price increase per box of 10 fresh eggs	€0 | €0.30 | €1.00 | €1.70

to pay an additional €0.50 to €1.00 per box of 10 eggs to "double the price or more". (The price of a box of fresh eggs in German supermarkets at the time of the study ranged from a minimum of €1.10 for conventional barn eggs to about €5.00 for organic eggs with additional production claims [e.g., dual-use poultry, regional agriculture, etc.]). Therefore, the levels of the price attribute are defined in a range of €0 to €1.70.

The design of the DCE was comprised of 2 alternatives and 4 attributes with 4 levels each, thus resulting in a full-factorial design of $[(4\cdot4\cdot4\cdot4)_{\text{Alternative A}} \cdot (4\cdot4\cdot4\cdot4))_{\text{Alternative B}} =]$ 65,536 possible choice sets. However, for the sake of practicability, this design was determined to be too extensive, and therefore, the number of choice sets was reduced. To minimize the simultaneous and unavoidable loss of information when reducing the full factorial design, a so-called "efficient design" was applied. Efficient designs (Rose and Bliemer, 2009) aim to minimize the standard errors of the utility parameters for the estimation process. These designs therefore require ex-ante information regarding the population's utility parameters. Thus, a pretest was conducted with 38 consumers to obtain the required information for the final experiment. This pilot study furthermore served to examine the comprehensibility of the questionnaire.

A D-optimal design (Scarpa and Rose, 2008; Rose and Bliemer, 2009) with 8 choice sets was found to be appropriate for the purpose of this study and was computed using the software ngene (ChoiceMetrics, Australia). An overview of all choice sets is given in Appendix A.

Data Collection

For the empirical analysis, primary data were collected from German consumers. An anonymous online survey was developed and available for participants from December 2018 to March 2019. Consumers were invited to participate in the survey by the data panelist "respondi" (respondi AG, Cologne, Germany). To obtain a representative picture of the German population, quotas on the variables age and education (highest educational attainment) were implemented. Furthermore, emphasis was made to achieve a sample which is geographically well distributed over Germany by implementing quotas on participants' postcode.

The questionnaire was structured as follows: first, consumers were asked to provide socioeconomic data. Furthermore, to understand whether participants were already aware that male chicks were culled, this information was requested through a multiple-choice question. Second, informational texts about the practice of chick culling and the in ovo technique were provided to participants. Participants' understanding of the information was verified through 2 multiple-choice control questions, which were integrated after the informational texts. In case an incorrect answer was given, both control questions could be repeated once. If respondents repeatedly failed to give the correct answer, they were excluded from the survey, as careless response behavior has to be assumed in these cases. Informational texts and control questions are provided in Appendix B. Another quality check was the integration of a Likert scale question, which read "please choose *rather reject*".

Third, the DCE was conducted. To ensure participants' understanding of the offered alternatives, a description of the attributes and levels remained available throughout the experiment by placing "mouse over buttons" in each choice set. By moving the cursor over the buttons, information became visible. To analyze the effect of pictures in the DCE, all participants were confronted with 2 DCE rounds. In the first round, the 8 choice sets were given as plain text; an example is depicted in Figure 1. Then, 4 pictures of incubated eggs and a chick were shown to participants, depicting the proposed levels of the attribute "day of gender determination". They are presented in Figure 2.

The pictures were then integrated into the choice sets; the picture corresponding to the level of the attribute "day of gender determination" was added to the former text that was describing the alternative. An example of a choice set with pictures is shown in Figure 3. All choice sets, now with pictures, were presented to participants a second time. A mouse over zoom was integrated so that the details of the pictures became more visible to consumers. In both DCE rounds, the 8 choice sets were randomized.

Econometric Approach

In the random utility theory (Luce, 1959; McFadden, 1974; Manski, 1977), which is the underlying framework for DCE, the estimation of respondents' preferences is based on the assumption that the respondents' choice is dependent on specific attributes, which characterize an alternative. Under the assumption of utility maximization, respondents choose the alternative for which they have the highest utility.

In discrete-choice models, the utility of alternative j perceived by respondent n in the choice situation t is denoted by Untj. Moreover, Untj is divided into 2

	Alternative 1	Alternative 2	I do not support any of the given alternatives
Day of gender determination	Day 4	Day 1	
Price increase per 10 eggs	€1,00	€1,00	
Usage of screened out eggs or chicks	Processing in the chemical industry	Pet food	
Percentage of wrongly sorted eggs or chicks	10%	5%	
Which alternative do you choose?	○	○	○

Figure 1. Example of a choice set (first choice experiment with text only).

components with a deterministic component Vntj and an unobserved component εntj:

$$U_{ntj} = V_{ntj} + \varepsilon_{ntj} \tag{1}$$

Focusing on the estimation of the WTP, the deterministic component can be described by the price component pntj p_{ntj}pntjpntj and the vector of nonprice attributes x_{ntj}, which are weighted by the respondent-specific, random parameters α_n and β_n :

$$U_{ntj} = -\alpha_n p_{ntj} + \beta_n' x_{ntj} + \varepsilon_{ntj} \tag{2}$$

Thereby, ε_{ntj} is assumed to be an independent and identically distributed error term following an extreme value distribution type 1. The variance of the error term is respondent specific and therefore defined as $Var(\varepsilon_{ntj}) = k_n^2(\pi^2/6)$, with k_n as scale parameter of respondent n. Because the utility is ordinal scaled, equation (2) may be divided by k_n without having an impact on U_{ntj} (Train, 2009). This results in:

$$U_{ntj} = -(\alpha_n / k_n) p_{ntj} + (\beta_n / k_n)' x_{ntj} + \varepsilon_{ntj} \tag{3}$$

Thereby, the variance of the error term is identical or rather constant for all respondents. By the standardization of k_n to 1, the variance is therefore redefined as $Var(\varepsilon_{ntj}) = \pi^2/6$. Defining the utility coefficients as $\lambda_n = (\alpha_n / k_n)$ and $\varphi_n = (\beta_n / k_n)$, utility can be written as follows:

$$U_{ntj} = -\lambda_n p_{ntj} + \varphi_n x_{ntj} + \varepsilon_{ntj} \tag{4}$$

Which is referred to as a model in *preference space*. In preference space, WTP for attribute levels is obtained by calculating the marginal rates of substitution between the attribute levels and the price parameter. Literature indicates that models in preference space seem to be the current standard method for estimating the WTP of individuals (see Sauter et al., 2016).

However, a main assumption of these models is that the price coefficient is fixed across individuals. This is necessary because otherwise the WTP is derived by calculating the ratio of 2 randomly distributed terms, namely the ratio of the distribution of the nonmonetary attribute and the distribution of the price coefficient ($WTP = \omega_n = \varphi_n/\lambda_n = \beta_n/\alpha_n$). Unfortunately, this procedure often results in unrealistic and invalid distributions for the WTP (Scarpa et al., 2008; Hensher and Greene, 2011). Handling the price coefficient to be fixed is an unnecessarily restrictive assumption as it does not allow to account for heterogeneity in the price coefficient, and furthermore assumes that the scale parameter and therefore the variance in the error term are identical for all individuals. Consequently, this unidentified scale heterogeneity can be erroneously attributed to a variation of the WTP (Train and Weeks, 2005). Considering this, models in so-called *WTP space* are able to overcome this problem by directly estimating WTP coefficients through a reformulation of the model to the following:

$$U_{ntj} = -\lambda_n p_{ntj} + (\lambda_n \omega_n)' x_{ntj} + \varepsilon_{ntj} \tag{5}$$

Where ω_n is directly calculated in the estimation process. In this case, assumptions regarding the distributions of the WTP are made directly rather than on the attribute coefficients.

In the case of this study, to test for differences between the single WTP estimates derived from the experiments with and without pictures, 2 approaches were used. First, the variable "treatment" was designed to describe the DCE round with pictures; interaction terms of all attributes with this variable were then included in the model estimation (model 1). Second, the 2 DCE rounds were estimated separately (model 2 and model 3), and a complete combinatorial method proposed by Poe et al. (2005) was applied subsequently. This so-called Poe test has become a standard for measuring the difference of independent empirical distributions in the

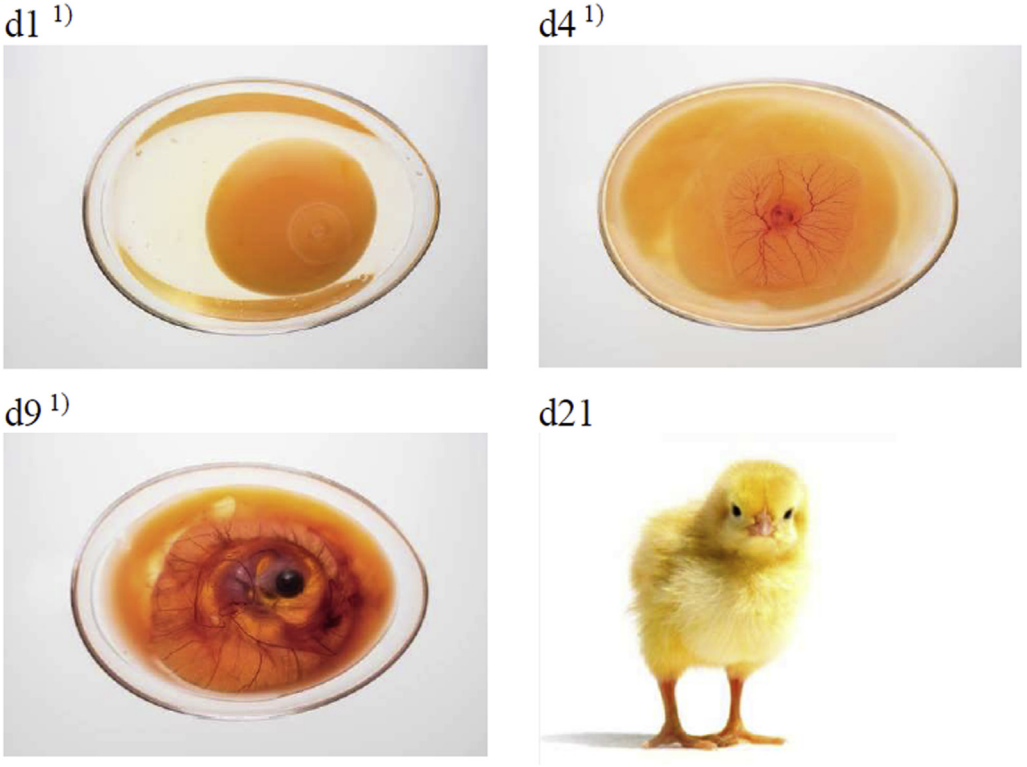


Figure 2. Pictures utilized in the choice sets of the second choice experiment. ([1]Source: Agri Advanced Technologies GmbH, Visbeck, Germany.)

context of the DCE in recent years. It is widely applied in the literature (Carlsson et al., 2005; Liebe et al., 2012, 2015; Colombo et al., 2015). In all three models, random parameter logit models in WTP space were used, which were estimated by using 1,000 Halton draws.

RESULTS

Socioeconomic Characteristics

A total of 125 participants were excluded prematurely from the survey. Of these, 56 because they answered the control questions incorrectly and 69 because they failed the quality check for straightlining. A total of 544 respondents completed the survey. However, data from respondents who always chose the same alternative in the DCE or attitudinal questions were excluded from the data set, as inaccurate answering behavior must be assumed in these cases. Thus, 482 respondents remained in the data set. The average answering time was 26 min. The socioeconomic characteristics of the respondents are depicted in Table 2. Through the implementation of quotas, the sample was achieved to be almost representative for the German population regarding the variables

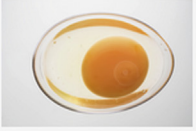
	Alternative 1	Alternative 2	I do not support any of the given alternatives
Day of gender determination	 Day 4	 Day 1	
Price increase per 10 eggs	€1,00	€1,00	
Usage of screened out eggs or chicks	Processing in the chemical industry	Pet food	
Percentage of wrongly sorted eggs or chicks	10%	5%	
Which alternative do you choose?	○	○	○

Figure 3. Example of a choice set (second choice experiment with text and pictures).

Table 2. Socioeconomic characteristics of the sample (N = 482).

Variable	Mean (SD)	Percentage %
Average age	49 [50][1,2] (17.6)	
Gender male		44 [50][2]
Education		
Apprenticeship		51 [56][2]
University degree		19 [18][2]
School leaving certificate or none		30 [26][2]
Residence		
Rural residence (town <20,000 inhabitants)		48 [41][3]
Urban residence (town > 500,000 inhabitants)		19 [17][3]
Occupation		
Students		4 [3][4]
Employees		50 [50][4]
Pensioners		35 [26][4]
Other		11 [21]

[1]German average given in brackets [].
[2]Destatis (2017).
[3]Destatis (2018).
[4]Destatis (2019).

Table 3. Model 1: RPL[1] model in the WTP space with interaction terms between attribute levels and the variable "treatment"[2] (N = 482)[3].

Variables	Mean
ASC[4] × treatment	−0.40***
d1 × treatment	0.85***
d4 × treatment	0.19**
d9 × treatment	−0.36***
d21 × treatment	[−0.68]
Error rate × treatment	−0.01
Chemical industry × treatment	0.11
Pet food × treatment	−0.03
Waste × treatment	0.02
Fodder × treatment	[−0.10]

Abbreviations: DCE, discrete-choice experiments; WTP, willingness to pay.
[1]Random parameters logit (RPL).
[2]The effects coded variable "treatment" is coded as −1 for the DCE without pictures and as 1 for the DCE with pictures.
[3]*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$; coefficients were estimated using 1,000 Halton draws. Base levels of effect-coded attributes in brackets []. For clarity, only coefficients for the interactions are shown. Complete results are displayed in Appendix C.
[4]Alternative-specific constant (ASC).

average age and education (highest educational attainment). The sample is furthermore representative for the German population regarding respondents' residence (rural or urban) and occupation group, as can also be seen in Table 2.

Evidence shows that participants were already widely aware of the culling of male chicks. A total of 79% of participants chose the correct answer in the multiple-choice question "What happens to male chicks from layer hen production?" (79% "they are culled"; 17% "I do not know"; 4% "they become broilers").

Examination of the Impact Pictures Have

The choice experiment data were analyzed using the software Stata 14. First, an effect-coded variable "treatment" that is coded as −1 for the DCE without pictures and as 1 for the DCE with pictures was created. (Effects and dummy coding differ in the handling of the attribute level, which describes the base level. With dummy coding, all nonomitted levels are coded as 0 when the base level is present. With effects coding, all nonomitted levels are coded as −1 when the base level is present (Hauber et al., 2016), which avoids confounding with the opt-out alternative.) Then, interaction terms of this variable with all attributes were included in the model estimation (model 1). Results of the interaction terms are presented in Table 3.

As can be seen in Table 3, statistically significant coefficients of the interaction terms give evidence for differences in respondents' answering behaviour between the with-picture and without-picture setting. A statistically significant negative alternative-specific constant (**ASC**) demonstrates that respondents were more inclined to opt out when pictures of incubated eggs and chicks were included in the choice sets, in comparison to plain text. Choice probabilities for the 2 in ovo alternatives executed on d1 and d4 of incubation significantly increased when respondents were provided with the pictures of incubated eggs.

In contrast, a statistically significant decrease of choice probability can be observed for in ovo gender determination at d9. Regarding the attribute "usage," no statistically significant changes in preferences between the 2 DCE are observed. In addition, regarding the preferences for the attribute "error rate," no statistically significant difference in preferences can be found between the 2 experimental settings.

In the next step, 2 separate random parameter logit models in the WTP space were estimated for the 2 DCE rounds with and without pictures. Differences in the distributions of coefficients were subsequently investigated using the Poe test. The results of both models are presented in Table 4. Both models reveal statistically significant coefficients for all attribute levels and for the ASC. The statistically significant ASC has a positive sign, meaning that respondents prefer to choose one of the alternatives offered in the DCE instead of the opt-out alternative. In ovo gender determination at all of the given days is preferred over the culling of chicks in both models. The Wald test was used to test for differences in WTP between the coefficients of the attribute "day of gender determination." Gender determination at d1 and at d4 do both generate a statistically significantly higher WTP than that at d9 in the without-picture alternative d1: $\chi^2 = 49.67$, $P > \chi^2 = 0.00$;d4: $\chi^2 = 56.37$, $P > \chi^2 = 0.00$. No statistically significant difference can be found between the coefficients of d1 and d4 ($X^2 = 0.18$, $P\,(> X^2) = 0.67$).

However, the Poe test reveals statistically significant differences in the choice behavior between the 2 DCE rounds, indicated in bold font in Table 4. Whereas a positive WTP for gender determination at d9 of incubation is found in the without-picture model, this changes in the with-picture setting. Choice probability significantly decreases for d9, rendering even a negative WTP for this

Table 4. Comparison of models 2 and 3 by means of the Poe test (N = 482)[1].

	Model 2—without pictures		Model 3—with pictures	
Variables	Mean	SD	Mean	SD
ASC[2]	1.98***	3.12***	1.41***	3.86***
d1	**1.47**[3]***	1.48***	**3.66*****	1.84***
d4	**1.45*****	0.54**	**2.22*****	0.49***
d9	**0.25***	0.28	**−0.81*****	1.40***
d21	[−3.17]		[−5.07]	
Error rate	−0.17***	0.09***	−0.22***	0.10***
Chemical industry	**−0.89*****	0.04	**−0.44*****	0.16
Pet food	1.58***	0.02	1.42***	0.02
Waste	−1.69***	1.69***	−1.86***	0.64***
Fodder	[1.00]		[0.88]	
Log likelihood		−3,273	−2,883	
Akaike Information Criterion		6,581	5,801	
Bayesian Information Criterion		6,713	5,934	

[1]* $P < 0.1$; ** $P < 0.05$; *** $P < 0.001$.
[2]Alternative-specific constant (ASC).
[3]In bold: differences in the mean WTP between the first discrete-choice experiment without pictures and the second discrete-choice experiment with pictures significant at 10% level based on the Poe et al. (2005) test; coefficients were estimated using 1,000 Halton draws. Base levels of effect-coded attributes in brackets [].

alternative. In opposition, WTP for the 2 early gender determination points d1 and d4 increases statistically significantly.

Preferences for the attribute "usage" are similar in both models. The use of the by-products, namely screened out eggs or male chicks, as pet food is the preferred utilization, followed by the use as fodder. Throwing by-products away as waste is the least preferred option and considerably reducing WTP for the associated alternative in both DCE rounds. The use of by-products in the chemical industry is also reducing WTP, although less strongly than the attribute level "waste." For the attribute level "chemical industry" we find a statistically significant change in choice behavior between the 2 DCE rounds. The attribute level is evaluated less negatively in the with-picture scenario. For the other attribute levels of the attribute "usage," no statistically significant difference in the choice behavior can be found between the 2 models.

The error rate in gender determination, associated with an increase of animals and incubated eggs needed, is considered a disadvantage. Respondents' WTP for a box of 10 eggs decreased by €0.17 when the error rate increased by one percent. In addition, for the attribute "error rate," no statistically significant difference in the choice behavior could be found between model 2 and model 3.

Both approaches, which were used for the comparison between the 2 experimental settings, show statistically significant changes in WTP for all levels of the attribute "day of gender determination," whereas preferences for the other attributes remain equal (with exception for the attribute level "chemical industry" of the attribute "usage"). This gives evidence that changes in the choice behavior can be assigned to the treatment, namely the provision of pictures.

DISCUSSION

The presented study addressed a highly topical subject regarding poultry production: gender determination of layer chicks in incubated eggs. The aim of this study was to investigate consumers' preferences for in ovo gender determination at different stages of embryonic development as an alternative to chick culling and to analyze the effect pictures have on these preferences. Findings reveal that all proposed in ovo alternatives were preferred over the current practice of chick culling, which is in line with findings from Gangnat et al. (2018). The provision of pictures influenced respondents' choice behavior significantly. When respondents were confronted with pictures, the attribute level "day 9" *decreased* choice probability in the with-picture scenario, whereas it *increased* choice probability in the scenario with plain text. This change in WTP for the attribute level "day 9" is particularly interesting. On d9 of incubation, the shape of the embryo already gives an idea of the future shape of the chick. As well as this, the eyes are already developed. In contrast, on d1 and d4 of incubation, no shape of a chick is visible yet, only the yolk. The association with a chick might be the reason for the disapproval of the attribute level "day 9" when accompanied with a picture. In this context, it can be instructive to take a look at the debate on abortion in humans. In Sweden, for example, the discourse on abortion was strongly and emotionally influenced by films and images of embryos in the media—in the interests of the antiabortionists (Jülich, 2018). Transferring these results to the subject of this study, the advanced developmental stage of the embryo on d9 of incubation could be an open flank of the corresponding in ovo technology.

Findings furthermore reveal that a meaningful utilization of the by-products of layer-hen production, screened out eggs or male chicks, is considered as a crucial characteristic and almost equally important as the day of gender determination. Surprisingly, the use of screened out eggs in the chemical industry is not considered desirable. In practice, this type of use could represent the main utilization of eggs. In this study, the use as pet food and fodder was preferred. This could be either due to the fact that these utilizations are more common to consumers or due to the fact that the utilization as a nutrient is considered superior to the utilization as an industry product. In addition, a certain reticence regarding the term *chemical industry* could have been a reason for the rejection. Especially in Europe, naturalness plays an important role in the context of food (Roman et al., 2017). However, at the beginning of the survey participants were explicitly informed that one possible use in the chemical industry is the production of shampoo, thus a rather common and uncritical product. Yet, all three possible utilizations were considered an improvement compared with "waste"/no use. In addition, a high accuracy in the gender determination process was considered important by respondents. An increase of the attribute "error rate" was as a

consequence penalized through a decrease in WTP. Therefore, high error rates or the lack of a meaningful utilization of incubated eggs can decrease approval for in ovo gender determination to an extent, where no positive WTP remains.

Results have important implications for stakeholders in egg production in Germany and also in other countries where the practice of chick culling is debated because of moral concern. The development of a technology enabling the sexing of chicken embryos at an early stage of development might be promising to meet the preferences of consumers. The results of this study reveal considerable WTP of consumers for these in ovo alternatives. This preference becomes clearer, when consumers are confronted with pictures of incubated eggs or a chick. Furthermore, findings imply that a low rate of failure and meaningful usage of screened out eggs should be communicated clearly to consumers, as it appears that they are crucial attributes for the acceptance of in ovo gender determination as a morally admissible alternative to chick culling. The communication of these attributes to interested consumers could be realized through informational texts on the packaging or through small flyers in the egg boxes. Dual-use poultry systems, for example, are already providing information about the rearing of male chicks in this way (e.g., Bruderküken—Initiative by the retailer Alnatura).

We find considerable WTP for certain observed attributes. However, WTP results obtained from stated preference experiments can be affected by a number of factors that might lead to a differing WTP observed at the point of sale. Reasons for this so-called hypothetical bias are described in a meta-analysis by Schmidt and Bijmolt (2020). For example, uncertainty about and innovativeness of a product might increase the hypothetical bias. Both is given in the context of eggs from in ovo–screened hens. Another source of hypothetical bias might be the use of a within-subject design. To test whether the results in this study are influenced by such an effect, a further study should use a between-subject approach. Moreover, having the chance to reveal a preference for an alternative to chick culling per se might result in a higher WTP. Future studies, comparing in ovo gender determination with chick culling, should analyze the mentioned sources of hypothetical bias. To validate the results of this study, consumers' WTP should be analyzed in a real buying decision.

This study aims at a direct comparison of the acceptance of in ovo gender determination and chick culling, whereas other alternatives such as, for example, dual-use poultry are not considered. As found by Reithmayer et al. (2019), a comparison of in ovo gender determination and dual-use poultry production reveals WTP for both alternatives, whereas the WTP is higher for in ovo gender determination. In the present study, potential preferences for such alternative options would be reflected in the ASC, which compares the general preference of consumers to choose in ovo gender determination and chick culling instead of the opt-out alternative. Other correlations of such preferences with attributes of this experiment are conceivable and should be subject to future research.

Results are particularly applicable in the market for shell eggs, where information on hens' husbandry system, dual-use systems, or gender determination of incubated eggs is already communicated to consumers through labels on egg boxes. Only to a limited extent can results be transferred to processed products containing eggs. The proportion of eggs in processed products is often relatively low, and in contrast to shell eggs, it is not necessary to provide information on the husbandry system of laying hens for eggs used in processed products in many countries. It must therefore be assumed that less interest in enhancing product attributes, as in ovo gender determination, exists for eggs in processed products—this could represent a future field of research.

The results demonstrate that as long as chick culling remains the industry standard, communication of "in ovo" production claims could be a way for producers to differentiate from the market. Our findings indicate that knowledge of societal expectations and a profound communication with consumers is able to increase WTP and acceptance for the in ovo technique considerably. However, gender determination at advanced stages of embryonic development is seen critical, especially when respective pictures of incubated eggs are provided. This offers a potential for social criticism, which should be kept in mind by stakeholders in poultry production when implementing the in ovo technique on a large scale.

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DISCLOSURES

The authors declare no conflicts of interest.

SUPPLEMENTARY DATA

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.psj.2020.09.092.

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