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Animal Production

6<sup>th</sup> International Workshop on  
Linear Profiling in the Warmblood Horse / Part I:  
video conference on 25 March 2020

## Correlation patterns between linear traits and their implications for breeding applications



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## Outline

- ❖ routine linear profiling as basis of the genetic evaluation for linear traits in the Oldenburg studbooks
  - ◆ key features of data structure
  - ◆ analytical approaches (trait definitions and modelling)
- ❖ patterns of estimated genetic parameters for linear traits and their interpretation
  - ◆ heritabilities
  - ◆ correlations (genetic and phenotypic)
- ❖ implications for breeding applications




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## Linear data basis (2012 - 2019)



- Oldenburg linear scheme (OL, OS)
  - conformation and performance (gaits / movement, jumping)
  - 7-point numeric linear scale (-3 to +3)  
defect traits / remarks: reduced scale (0 to +3)
  - foals, mares, stallions  
(registration, studbook inspection, mare performance test, preselection for licensing)
- extension of linear data collection (routine)
  - most/all events since 2015
  - in Germany and abroad
  - kernel team of experienced assessors

➤ **in total N=24,276 linear profiles of 22,891 horses**  
(varying depth = numbers of traits depending on assessment type)

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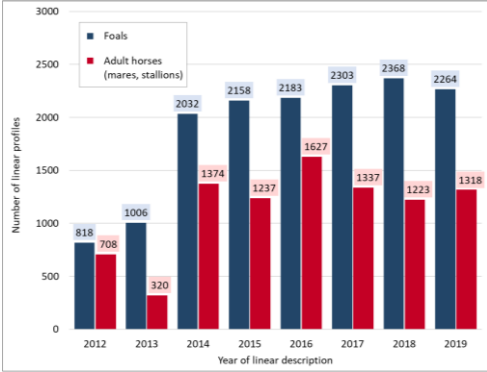
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## Distribution of linear data

- in total 24,276 linear profiles
- 2:1 relation between age groups
  - about 15,100 foals (62%)
  - about 9,100 adult horses (7,264 mares, 1,880 stallions)



➤ optimum use of linear data across age groups



Year of linear description	Foals	Adult horses (mares, stallions)
2012	818	708
2013	1006	320
2014	2032	1374
2015	2158	1237
2016	2183	1627
2017	2303	1337
2018	2368	1223
2019	2264	1318

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## Distribution of linear data II

- in total 24,276 linear profiles
- wide range of traits
  - 'standard' descriptors (e.g. length of neck, suppleness in trot)
  - rare characteristics (e.g. broken toe axis FL/HL, tail tone)
- varying conditions of linear description
  - presentation in hand
  - free movement and free jumping
  - presentation under rider



*Tab.: Information structure of the linear data*

Trait category	No. of linear traits: assessed (total) → included in GE	No. of assessments per event	
		foals (F)	adults (A)
Conformation	74 → 23	1	1
Walk (H, F, R)	6 → 2	1	1 - 2
Trot (H, F, R)	12 → 6	1	1 - 3
Canter (F, R)	10 → 4	(1)	2 - 3
Jumping (F) → (F, R)	16 → 10	0	1 (1 - 2)
Special remarks (H, F, R)	8 → 1	1	1 - 3
Behavior (H, F, R)	9 → 0	1	1 - 3

H = in hand, F = free, R = under rider; GE = genetic evaluation

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## Genetic analyses of linear data

- estimation of genetic parameters
  - genetic evaluation (GE) = prediction of breeding values
- in larger intervals: re-estimation (update) of genetic parameters
  - routine GE 2019 / "Vererbungsprofil 2020": genetic parameters from 2018 estimated on the basis of approx. 20,000 linear profiles
- optimization and quality control through refined analyses
  - different trait definitions
    - within age group (as in the routine GE) or
    - within age group and presentation type
  - different modelling
    - single- vs. multiple-trait model
    - single vs. repeated observations

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## Trait definition for refined analyses I

- within age group
  - underlying assumption: analogue linear traits in foals (F) and adults (A) are (possibly / likely) genetically related, but not identical

model / prediction system (routine genetic evaluation):  
 single- and multi-trait repeatability linear animal models

$Y_{ijkno} = \mu + SB_i + EVENT-TEAM_j + AGE\_M_k + SEX_l + animal_o + e_{ijklop}$  (foals)



$Y_{ijmnop} = \mu + SB_i + EVENT-TEAM_j + AGE\_Y_m + \boxed{PTYPE_n} + animal_o + \boxed{pe_o} + e_{ijmnop}$  (adults)

fixed effects: SB = studbook (OL, OS), EVENT-TEAM = date, place, assessor, assistance, SEX = male / female, AGE\_M (AGE\_Y) = age in months (years), PTYPE = presentation type (assessment in hand, free, under rider);  
 random effects: animal = additive genetic effect, pe = permanent environmental effect of the animal

TROT Impulsion / F	TROT Impulsion / A - in hand
	TROT Impulsion / A - free movement
	TROT Impulsion / A - under rider

2 traits (1x foals + 1x adults)

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## Trait definition for refined analyses II

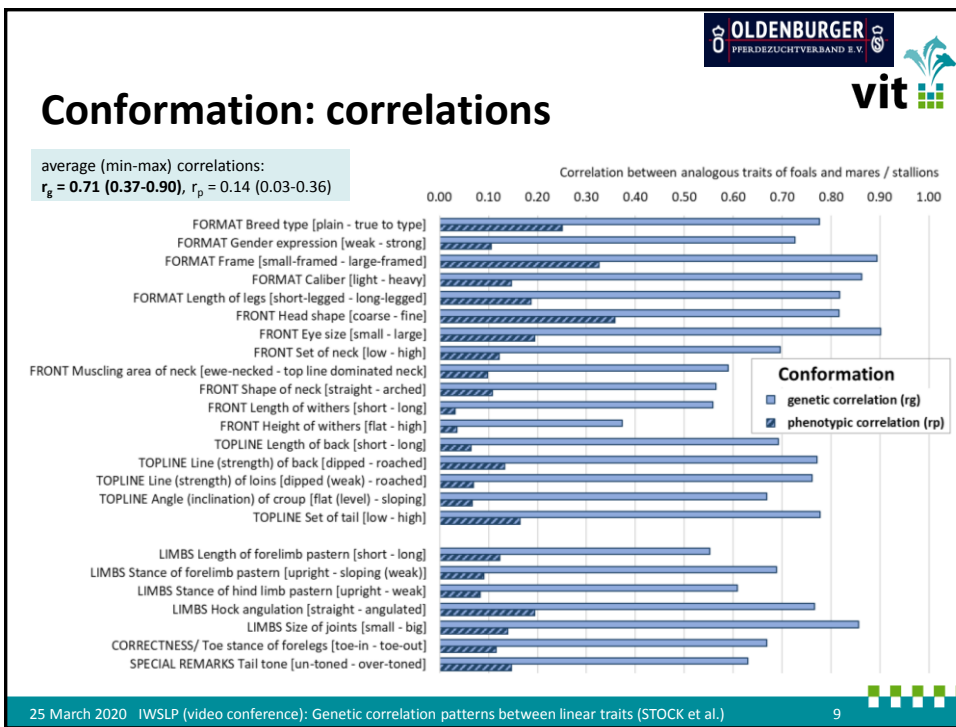
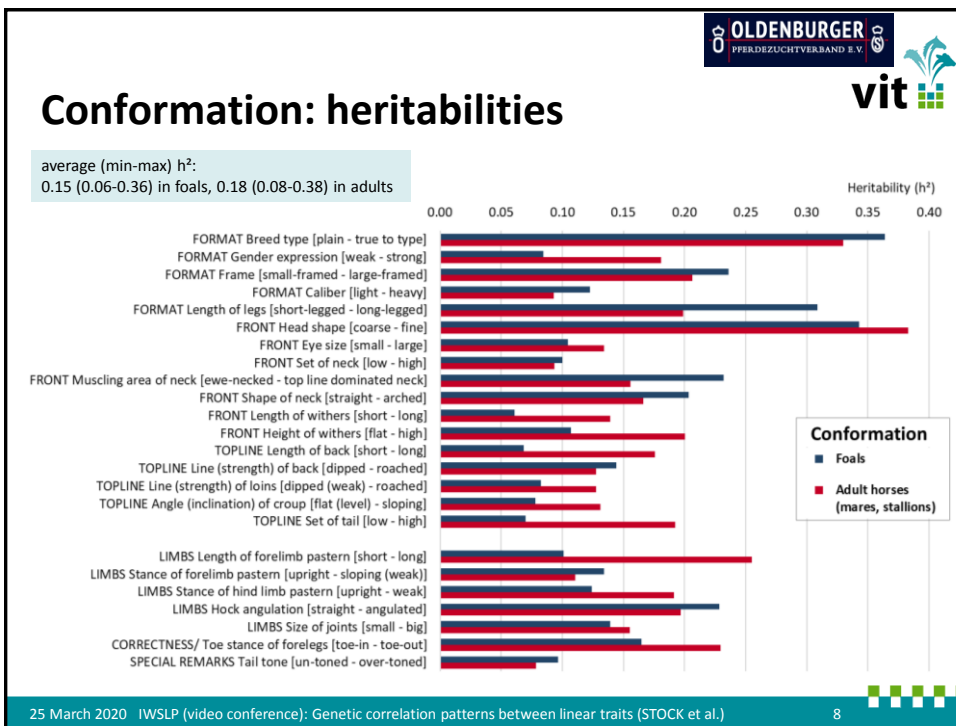
- within age group
  - underlying assumption: analogue linear traits in foals (F) and adults (A) are (possibly / likely) genetically related, but not identical
- within age group and presentation type
  - intention: quantification of genetic (dis-)similarity of linear traits recorded in the same age group under different conditions

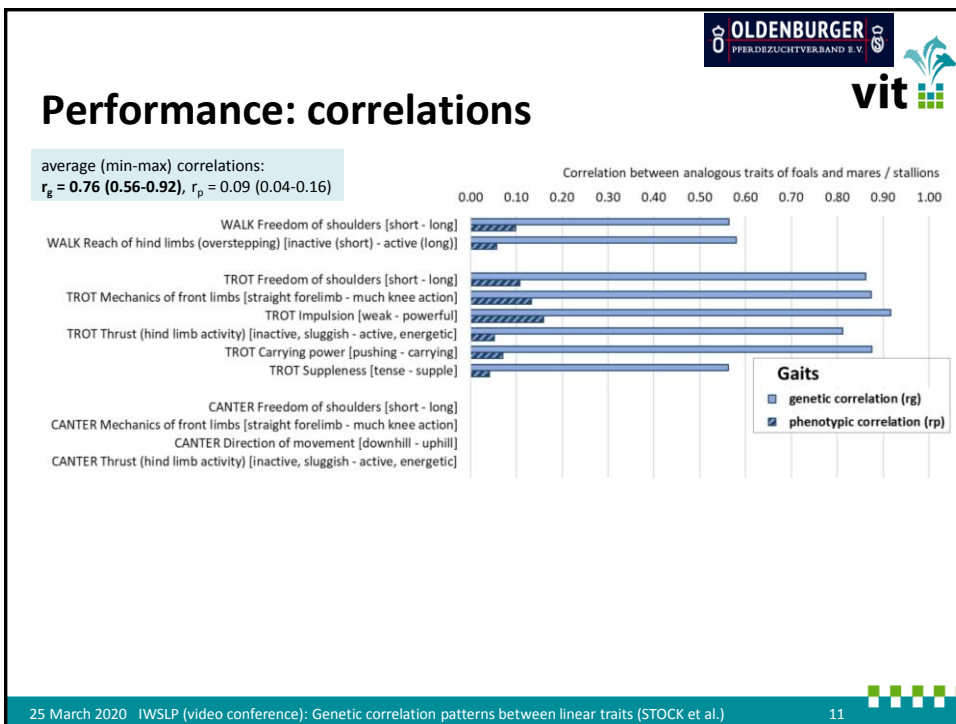
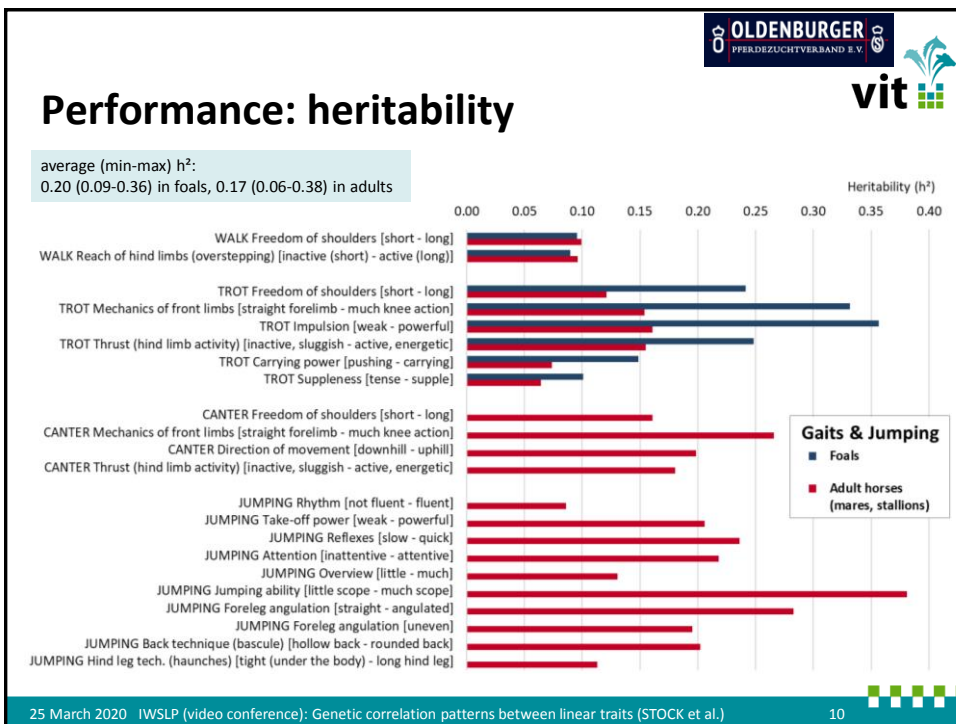
➤ value of multiple-trait and appropriateness of repeatability model  
 (H/F/R trait values = repeated observations of the same trait)



TROT Impulsion / F	TROT Impulsion / A - in hand	TROT Impulsion / F	TROT Impulsion / A - in hand	TROT Impulsion / A - free movement	TROT Impulsion / A - under rider
	TROT Impulsion / A - free movement	↑			
	TROT Impulsion / A - under rider	↑			

2 traits (1x foals + 1x adults)
4 traits (1x foals + 3x adults)

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## Performance: refined analyses I

diagonal:  $h^2$   
upper (lower) triangle:  $r_g$  ( $r_p$ )

TROT Freedom of shoulders [short - long]	F	A hand	A free	A rider
F	<b>0.248</b>	0.853	0.852	0.884
A hand	0.097	<b>0.113</b>	0.923	0.965
A free	0.156	0.213	<b>0.120</b>	0.820
A rider	0.160	0.210	0.271	<b>0.240</b>



  

TROT Mechanics of front limbs [straight forelimb - much knee action]	F	A hand	A free	A rider
F	<b>0.342</b>	0.951	0.861	0.803
A hand	0.168	<b>0.116</b>	0.976	0.876
A free	0.201	0.336	<b>0.315</b>	0.872
A rider	0.210	0.248	0.388	<b>0.238</b>

TROT Impulsion [weak - powerful]	F	A hand	A free	A rider
F	<b>0.367</b>	0.931	0.953	0.801
A hand	0.157	<b>0.169</b>	0.993	0.844
A free	0.212	0.287	<b>0.251</b>	0.819
A rider	0.214	0.237	0.359	<b>0.257</b>

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## Performance: refined analyses II

diagonal:  $h^2$   
upper (lower) triangle:  $r_g$  ( $r_p$ )

TROT Thrust (hind limb activity) [inactive, sluggish - active, energetic]	F	A hand	A free	A rider
F	<b>0.259</b>	0.852	0.811	0.829
A hand	0.039	<b>0.141</b>	0.925	0.917
A free	0.125	0.333	<b>0.269</b>	0.924
A rider	0.146	0.205	0.309	<b>0.217</b>



  

TROT Carrying power [pushing - carrying]	F	A hand	A free	A rider
F	<b>0.146</b>	0.910	0.754	0.794
A hand	0.075	<b>0.054</b>	0.958	0.868
A free	0.101	0.206	<b>0.104</b>	0.812
A rider	0.126	0.081	0.186	<b>0.137</b>

TROT Suppleness [tense - supple]	F	A hand	A free	A rider
F	<b>0.106</b>	0.790	0.691	0.311
A hand	0.059	<b>0.067</b>	0.834	0.640
A free	0.069	0.141	<b>0.083</b>	0.902
A rider	-0.026	0.058	0.147	<b>0.112</b>

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## Performance: refined analyses III

diagonal:  $h^2$   
upper (lower) triangle:  $r_g$  ( $r_p$ )

WALK Freedom of shoulders [short - long]	F	A hand	A free	A rider
F	<b>0.097</b>	0.629	n.a.	0.552
A hand	0.091	<b>0.082</b>	n.a.	0.977
A free	n.a.	n.a.	n.a.	n.a.
A rider	0.065	0.250	n.a.	<b>0.153</b>



  

WALK Reach of hind limbs (overstepping) [inactive (short) - active (long)]	F	A hand	A free	A rider
F	<b>0.090</b>	0.632	n.a.	0.520
A hand	0.059	<b>0.084</b>	n.a.	0.912
A free	n.a.	n.a.	n.a.	n.a.
A rider	0.061	0.263	n.a.	<b>0.142</b>

SPECIAL REMARKS Tail tone [un-toned - over-toned]	F	A hand	A free	A rider
F	<b>0.099</b>	0.558	0.786	0.595
A hand	0.090	<b>0.046</b>	0.951	0.775
A free	0.028	0.102	<b>0.212</b>	0.797
A rider	0.054	0.147	0.254	<b>0.137</b>


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## Summary & implications

### Genetic parameters for linear traits I

- plausible and consistent patterns of heritabilities ( $h^2$ )
  - relatively low  $h^2$  of  $< 0.10$  for behavior and certain aspects of conformation / performance → not (yet) included in genetic profiles
  - reasonable numbers of traits with  $h^2 > 0.2$  in both age groups



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## Summary &amp; implications

## Genetic parameters for linear traits II



- plausible and consistent patterns of heritabilities ( $h^2$ )
  - relatively low  $h^2$  of  $< 0.10$  for behavior and certain aspects of conformation / performance → not (yet) included in genetic profiles
  - reasonable numbers of traits with  $h^2 > 0.2$  in both age groups
- genetic correlation patterns supporting the multiple trait approach
  - impact of assessment conditions (presentation type) on linear profiles → repeatability model
  - genetic similarity of analogous traits assessed in foals and adult horses

➤ **high value of linear foal data (broad basis, early prediction)!**



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# Thank you!

- high value of linear foal data (broad basis, early prediction)!
- support of expectations regarding linear profiling
  - reliable 'filtering out' of genetic dispositions (better than phenotype-based progeny statistics)
  - earlier, more objective and more helpful information for breeders

Contact information (vit\_Genetic evaluation division / R&D):

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