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Latent variable models on performance tests in guide dogs. 1. Factor analysis

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ABSTRACT

The research has been conducted on behavioural test results obtained from 143 dogs of pedigreed stock reared in the National Guide Dog School (SNCG) of Scandicci (Firenze, Italy), consisting mostly of Labradors and Golden Retrievers, but also including German Shepherds. All dogs have been reared under quite uniform conditions and tested individually under similar conditions.
The results following the 11 administered subtests, [that constitute variables in our analysis], were expressed in scores ranging from 1 to 5 and used after calculation of the rank averaged scores.
The analysis of the Pearson and partial correlations between the variables points out a clean distinction in two groups. The first consists of variables related to characters of sociability and to relationship with the handler, with expression of dominance/submissiveness and the second to characters of reaction to external stimuli with expressions of fearfulness/curiosity.
Results of factor analysis led us to reject the one factor model and accept a model with two factors, in which: 1) Factor I identifies variables of the group tied to the fearfulness/curiosity; 2) Factor II identifies the variables of the group tied to sociability and to relationship with the handler.
The two factors are correlated, indicating the presence of some non negligible, indirect effects.
One out of the eleven variables has not shown important evidence of contribution to any of the factors.

Key Words: Dog, Performance tests, Factor analysis, Latent variable models.

RIASSUNTO

MODELLI A VARIABILI LATENTI SULLE ASSOCIAZIONI TRA PERFORMANCE TEST IN CANI GUIDA. 1. ANALISI DEI FATTORI.

La ricerca è stata condotta su 143 cani di razza Labrador, Golden Retriever e Pastore Tedesco allevati presso la Scuola Nazionale Cani Guida di Scandicci (SNCG), Firenze. Tutti i cani analizzati sono stati allevati in ambiente uniforme e sottoposti al test nelle medesime condizioni. I risultati seguenti alla somministrazione degli 11 test, costituenti le variabili analizzate, sono espressi in punteggi con range da 1 a 5 e utilizzati dopo calcolo della media dei ranghi.
L'analisi delle correlazioni semplici e parziali tra le variabili indica una netta distinzione in due gruppi di variabili correlate tra loro. Il primo gruppo è composto da variabili legate a caratteri di socievolezza e al rappor-

to con l'uomo con espressione di dominanza/sottomissione, il secondo da caratteri di reazione a stimoli esterni con espressioni di paura/ansia.
I risultati dell'analisi dei fattori fanno rifiutare il modello ad un fattore e consentono di accettare un modello a due fattori, in cui: 1) il fattore I identifica le variabili del gruppo legate alla paura/ansia; 2) il fattore II identifica le variabili legate alla socievolezza e al rapporto con l'uomo.
I due fattori sono tra loro correlati, indicando la presenza di alcuni effetti indiretti non trascurabili.
Una delle undici variabili non contribuisce in modo considerevole a nessuno dei fattori.

Parole chiave: *Cani, Performance test, Analisi dei fattori, Modelli a variabili latenti.*

Introduction

The performances of working dogs are animal productions that lay within the realm of behavioural sciences and are the basis of their selection for breeding purposes. Since 1950 many researchers have studied dog behaviour with different aims: simply comparing it with the evolution of other mammal behaviour or, more often, to find characteristics that can be utilized for early age selection and breeding.

Studies on the behaviour of dogs have been published by many authors since 1950. Most of them have devoted their attention to the physiological or pathological development of behaviour in the dog as a result of its interaction with human society and interesting results concerning the dogs' attitude in relation to their growing environment have been observed (Anastasi *et al.*,1955; Pfaffenberger, 1984; Svartberg, 2002; Svartberg, 2005). In recent decades even studies on working dogs behaviour have been undertaken. Field studies on working dogs have focused on the "ideal" characteristics of the good working dog in relation to its working function (Wilsson and Sundgren, 1997; Serpell and Hsu, 2001; Svartberg, 2002; Voltini and Leotta, 2003) with consequent improvement in knowledge in terms of breeding and training (Goddard, 1979; Champness, 1996).

Working with behaviour involves dealing with many measurable variables, but also with some unobserved (latent) variables. Many statistical techniques have been developed for dealing with situations in which multiple variables, (some unobserved), are involved. In recent years, with the advent of powerful digital computers and associated software, it has been feasible for any interested behavioural researcher to take a multivariate approach to proper data.

Latent variable models is a term encompassing specific methods of multivariate analysis such as Factor Analysis, Path Analysis and Structural Equations Modeling (SEM) (Bentler and Weeks, 1980; Everitt, 1984; Bollen, 1989; Pearl, 1997; Shipley, 2000; Loehlin, 2004) that have some common features including:

- multiple variables, where three or more are involved;
- one or more of these variable are unobserved, or *latent*.

A recent upsurge in the analysis of animal behaviour has consequently improved the use of different techniques of multivariate analysis.

Factor analysis (FA) may prove to be one of the methods useful in collating the diverse observations resulting from behavioural tests (Fuller and Thompson, 1960).

Within human personality research, where the study of personality traits has a long tradition, factor analysis has been used since the beginning of the twentieth century (Digman, 1990).

Since the early '50's, there have been attempts to apply factor analysis to animals. Many factor analysis studies have been published, most of which were performed on mice (Furchtgott and Cureton, 1964; Royce *et al.*, 1973; Simmel and Eleftheriou, 1977), fewer on chicks (Dunlap, 1933), or dog behaviour (Anastasi *et al.*, 1955; Svartberg and Forkman, 2002; Svartberg, 2005).

The reason for the infrequent use of this technique in these species stems from the difficulty in meeting certain important methodological requirements such as test reliability, a sufficient number of variables to permit adequate determination and definition of each factor, and a large

Table 1 Breed and sex distribution of dogs.

Breed	Male	Female	Total
Golden Retriever	27	31	58
Labrador	34	40	74
G. Retriever x Labrador	3	4	7
German Sheperd	3	1	4
Total	67	76	143

enough group of subjects so that chance errors of sampling will not affect the correlation coefficients too much. Owing to their failure to meet one or more of these conditions, even the best available factorial investigations of infrahuman behaviour must be regarded as preliminary and exploratory. Anastasi *et al.*, (1955), in their study on factor analysis of performance on certain learning tests, have limited their analysis to exploratory factor analysis without any use of Structural Equation Modeling (SEM) or Wright's Path Analysis. The same goes for studies by Svartberg and Forkman (2002) and Svartberg (2005).

Wright's method of Path Analysis (PA) (Wright, 1921) had been largely rediscovered by social scientists, with the important difference that the emphasis shifted from being an *a posteriori* description of an assumed causal process - as Wright viewed his method - to being a tentative test of an assumed causal process (Shipley, 2000).

Path coefficients in factor analytic writing are called the factor pattern coefficients, or more simply, the factor loadings.

Loehlin (2004), illustrates an alternative way of representing a path diagram as a set of *structural equations* (SE). Here, each equation expresses a downstream variable as a function of the causal path leading into it. There are as many equations as there are downstream variables.

The Structural Equation approach to causal modeling originated in Economics, and the Path approach in biology. For many purposes the two may be regarded simply as alternative representations. Note, however, one difference: path diagrams explicitly represent the correlations among source variables, whereas structural equations do not. If using the latter, supplementary specification or assumptions must be made concerning the variances and covariances of the source variables in the model.

Biology and psychology, dealing with events within the organism, tend to place an earlier emphasis on the latent variable versions of path analysis.

Analysing the information that emerged from the dogs' evaluation tests, we hypothesise that stimuli administered with subtests can be viewed as measures (imperfects) of one or more unobserved variables (the factors or latent variables in the language of Path Analysis) that can be related to the ability to become a good guide dog.

The objective of this work is to verify if such a formulation can be accepted using a method of Factor Analysis to extract and interpret a latent

Figure 1. Scree Plot

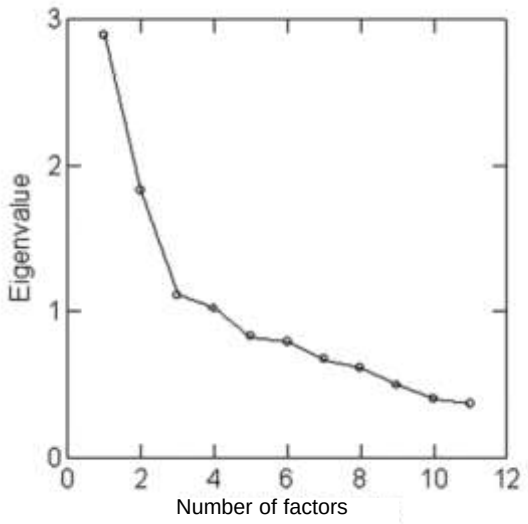

Table 2. Correlations between variables and statistics (mean and standard error). Pearson correlations (below diagonal) and partial correlations (above diagonal).

	RI	RP	CON	SE_1	CUC	RU	GRI	TAV	OMB	CAR	RAP
RI	1	.41**	-.01	.26**	.15	-.09	.06	-.09	.06	-.01	-.07
RP	.47**	1	.22**	-.11	.14	.03	-.04	.10	-.10	-.11	.03
CON	.24**	.32**	1	.26**	.18*	.05	.02	-.01	.09	-.04	-.10
SE_1	.33**	.16	.33**	1	.14	.11	-.04	.04	-.20*	-.03	.25**
CUC	.32**	.30**	.34**	.32**	1	.01	.13	.01	.10	.24**	.20*
RU	-.02	.03	.14	.09	.18*	1	-.03	.08	.38**	.14	-.02
GRI	.09	.08	.12	.05	.29**	.18*	1	.51**	.15	.05	.08
TAV	.03	.11	.11	.10	.27**	.24**	.58**	1	.09	.12	.17*
OMB	.03	.01	.13	-.07	.22**	.43**	.32**	.30**	1	.01	.06
CAR	.01	-.03	.05	.06	.30**	.23**	.24**	.28**	.19*	1	.04
RAP	.07	.08	.07	.29**	.30**	.10	.10	.24**	.11	.16	1
Mean	4.60	4.56	4.64	4.63	4.57	4.32	4.24	4.22	3.62	4.60	4.48
SE	.057	.064	.058	.055	.059	.076	.076	.079	.089	.057	.066

Coming on recall (RI), retrieving (RP), dominance (CON), following aptitude (SE_1), curiosity toward a big windowed box in the middle of the room (CUC), reaction to noise (RU), walking on anomalous surface as grilled ground (GRI), passage on a weighing plank (TAV), umbrella test (OMB), reaction to moving trolley (CAR) and reaction to a big puppet-dog (RAP).

*** Probability value, P< .01.*

** Probability value, P< .05.*

(or more latent) variable(s) that explains relationships between observed variables (subtests).

Material and methods

Animals

Test results were obtained from 143 dogs of pedigreed stock bred at the SNCG of Scandicci (Florence, Italy). All dogs were reared under quite uniform conditions: birth and first two months in a home environment (the home of the family to which the bitch was entrusted); then from 8 weeks to 12 months the dogs stayed at puppy walker families. Puppy walker families are chosen by their minimum availability of time to spend with the dog, to give it as much environmental stimuli as possible.

The 143 dogs consist mostly of Labrador and Golden Retrievers, but there are also German Shepherds and a litter from a cross between a Labrador stud dog and a Golden Retriever bitch (Table 1).

Performance Tests

Our study was based on performance tests performed on dogs bred at the SNCG since 1999. The Training Programme that dogs of SNCG follow is always the same and the evaluation part is – described as follows: at the age of 12 months, puppies return to the school and are submitted to the test for the evaluation of their aptitude to become a guide dog before being allowed into the training session. These tests are composed of 11 different subtests, which should account for the dog's attitude to be trained as a guide dog.

Dogs are tested individually under uniform conditions. The test is carried out in a very large room by the test supervisor who assesses the dog's reaction to the situation submitted to the dog by the test handler, assigning a score for each subtest. The dog supervisor must always be

Table 3. Factors pattern, initial communalities (h^2) and percent of total variance explained.

Variable	Factor I	Factor II	h^2
RI	.36	.54	.32
RP	.35	.46	.30
CON	.39	.33	.24
SE_1	.34	.37	.29
CUC	.62	.22	.36
RU	.34	-.18	.23
GRI	.61	-.33	.39
TAV	.64	-.36	.41
OMB	.41	-.26	.29
CAR	.37	-.18	.18
RAP	.34	.04	.18
% of total variance explained	20.26	10.65	

Coming on recall (RI), retrieving (RP), dominance (CON), following aptitude (SE_1), curiosity toward a big windowed box in the middle of the room (CUC), reaction to noise (RU), walking on anomalous surface as grilled ground (GRI), passage on a weighing plank (TAV), umbrella test (OMB), reaction to moving trolley (CAR) and reaction to a big puppet-dog (RAP).

the same; the test handler can be one of three certified dog instructors which are assigned to the test sessions.

Performances on each of the 11 subtests are evaluated with a score from 1 to 5, where a low score equals a type of reaction, which is unwanted in a future working dog, and a higher score corresponds to a desired reaction by the dog. Wanted and unwanted reactions are pre-defined in a standardised score sheet developed by the same veterinarian who introduced the test to the SNCG in 1999.

After the dog is brought into the room on a leash, doors are closed to avoid other persons coming in during the test. The dog is unleashed and the test starts. The 11 subtests are: coming on recall (RI), retrieving (RP), dominance (CON), following aptitude (SE), curiosity toward a big windowed box in the middle of the room (CUC), reaction to noise (RU), walking on an anomalous surface such as grilled ground (GRI), passage on a weighing plank (TAV), umbrella test (OMB), reaction to moving trolley (CAR) and reaction to a big puppet-dog (RAP).

Statistical analysis

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was calculated on data set prior to submitting it to Factor Analysis (SPSS, 1990).

The mode of approaching data in this particular latent variable model, and specifically in Factor Analysis, was the so-called *R-technique* (Cattell, 1952), where the aim is to factor the relationships among tests (or measures) that are correlated for a sample of subjects (dogs) based on a single occasion of measurement (Loehlin, 2004).

Analyses were conducted on the observed correlation matrix of the rank averaged scores.

Maximum Likelihood analysis was employed for estimation of communality and extraction of common factors.

A criterion employed for determining how many factors to extract was based on the Scree Plot test. The users plots successive eigenvalues on a graph (Figure 1) and arrives at a decision based on the point at which the curve of decreasing eigenvalues changes from a rapid, decelerating decline to a flat gradual slope (Loehlin, 2004).

Table 4. Rotated pattern and structure, final communalities (h^2) and percent of total variance explained. Factor loadings > 0.35 are shown in bold.

Variable	Pattern (P)		Structure (S)		Final communalities
	I	II	I	II	h^2
RI	-.12	**.67**	.07	.64	.42
RP	-.07	**.59**	.10	.58	.34
CON	.06	**.49**	.20	.51	.26
SE_1	-.01	**.51**	.13	.50	.25
CUC	.31	**.51**	.45	.59	.44
RU	**.39**	.01	.39	.11	.15
GRI	**.69**	-.01	.69	.18	.48
TAV	**.74**	-.03	.73	.18	.54
OMB	**.50**	-.05	.49	.09	.24
CAR	**.41**	.01	.41	.12	.17
RAP	.22	.20	.28	.26	.11
% of total variance explained	16.23	14.68			

The χ^2 test of goodness of fit was also employed. It resulted significant for all models inferior or equal to 3 factors. Considering that, in general, it overestimates the number of factors, and considering parsimonious and simplicity interpretation criteria we accepted the 2-factor model.

In relation to judging with regard to extraction of factors and correctness with respect to the fitting of the model, the analysis of residual correlation matrix was also performed on the 2-factor model. Only 4 out of 55 correlations resulted higher than |.10|, with a maximum of |.14|.

Furthermore, an oblique rotation method was employed to allow the best interpretation of factors, with a gamma=0 value to account for moderate correlations. Statistical analysis was conducted with Systat Version 9.11 (Systat, 1999).

Results and discussion

Table 2 reports the Pearson and partial correlations among the 11 performance tests and related statistics.

Looking at the correlations, there is evidence that there are two consistently distinguished groups of correlated variables; a group of the first 5 variables and a second group of the last 6 variables. The type of stimulus given with the tests of each group are, in fact, quite similar. In the group of the first five variables there are all tests regarding the interaction with humans (RI, RP, SE), regarding *dominance* and the opposite *submissiveness* (CON), and the fact that they are correlated to one another confirms this. The variables CUC and SE, although belonging to the group of the first five variables, shows correlations to variables from the second group: SE with RAP, but CUC with all the remaining. Furthermore, the kinds of stimuli given with the last six variables are all tests regarding reactions to strange situations (TAV, CUC, GRI) or loud noise (RU) or frightening objects (CAR, OMB). These two grouped correlations between variables let us hypothesise that factor analysis will lead to a model with more than one factor.

Factor Analysis – The KMO measure of sampling adequacy resulted in 0.686, confirming the

adequacy of the data to be submitted to factor analysis.

Table 3 reports the factor pattern, showing the factor loadings of the 11 variables on each factor, as well as the initial communalities, and the proportion of total variance explained by factors.

The centroid axes were next rotated in such a way to maximize the number of zero factor loadings (simpler structure), with use of the oblimin method to account for correlation between factors. The rotated pattern is reported in Table 4. Correlation between factors resulted in 0.28, evidencing the presence of some non negligible indirect effects of which there is evidence with the inspection of correlations between factors and variables in the structure matrix (Table 4).

If the communalities (h^2) are low, some potential factors may have zero correlations with others (Mc Donald and Mulaik, 1979). In our case the communalities are quite high (Table 4) except for CAR (0.17), RAP (0.11) and RU (0.15).

Percent of total variance explained by factors was 30.91 (respectively, Factor I = 16.23 and Factor II = 14.68), according to values reported by Anastasi *et al.* (1955) that in their research, obtained a value of 33.4, using 17 tests that allowed the extraction of 5 factors, of which, Factor I and II (similar to our factors) showed 10.0 and 12.0 of total variance, respectively. In our study the rate of reduction in dimensionality (2/11 *vs* 5/17) had a better result.

In order to achieve a useful psychological interpretation of factors, all variables having loadings of ± 0.35 or higher on each factor were examined. Such a factor loading accounts for more than 12% of the variance of the related variable. Reference to Table 4 shows those variables which meet the above criterion.

The type of behaviour involved in all the variables that meet the criterion for the interpretation of Factor I, (RU, GRI, TAV, OMB and CAR), is that these are all types of subtests that concern frightening stimuli, so that this factor can be labelled as "fearfulness" or even the opposite "fearlessness." Further confirmation to this interpretation is the outcome of Svartberg and Forkman (2002) and Svartberg (2002, 2005) studies on dogs' personality traits and breed-typical behaviour where a factor labelled "Curiosity/fearlessness" have been found. In fact, although in these studies it has been considered the opposite reaction (fearlessness) toward our study (fearfulness), it is a description of a reaction to a frightening stimulus.

Regarding the interpretation of Factor II; results suggest that this factor may be related to the dog's sociableness and to the dog's eagerness to take part in exercises (RP) or activities (RI, SE) with humans and its submissiveness to be put in constrained position (CON). This factor appear to involve docility and responsiveness to humans as reported in a research by Anastasi *et al.* (1955) and in more recent studies by Svartberg and Forkman (2002) and Svartberg (2005).

The variable RAP does not have sufficiently high loadings (and so far, communality) for any of the two factors, so the analysis seems to indicate that RAP have no relations with other variables. This may be explained assuming that the kind of stimulus it gives includes different components of behaviour not related to the ones evidenced, or that this subtest does not represent any behavioural component at all.

Conclusions

The hypothesis regarding a "general factor model" can be safely rejected. It is not acceptable to explain associations between variables. There are more complex models of relations with more correlated factors.

The simpler model that generates a correlation matrix compatible with the observed matrix indicates that we can identify 2 factors (or latent variables) that can be assumed as causes of 10 out of 11 variables. The reduction achieved in dimensionality was consistent.

Looking at results, we can say that a model of factor analysis has three great merits:

1) it can be achieved by straightforward procedures from data;
2) it establishes how many factors are necessary to explain the data to an acceptable degree of precision;
3) it suggests that some variables, like RAP in our case, can be excluded from analysis of further latent variable models. (This doesn't necessari-

ly mean that for the evaluation of the dog this subtest is useless).

Concerning general statistics of performance tests, an observation can be made regarding the distribution of each variable. Though each variable has the minimum number of levels indicated for use in Factor Analysis, instructors whom had observed the test and scored each dog were probably not sensitive enough to assign every score level giving instead mostly a score of 3, 4 and 5. So assumptions on multivariate distributions can be somehow forced. Further studies on how to preadjust data may likely be useful. Nevertheless, observed results are of interest, allowing some speculations and subsequent formulation of further latent variable models for further investigations on the basis of the evidence in the present study. In our case, in fact, it is possible to state that Factor I is an indicator of a sort of reactivity for "self safety" in the dog, while Factor II is more representative of the dog's relation with humans (the test handler).

Indeed, this 2-factor model assumes that every cause (latent variables or latent factors) influences everything, but causes typically have a limited range of effects (Loehlin, 2004), and real life causal influences may often be correlated.

An interesting and useful step could be to test models in which each factor influences only few variables, without any consideration of variables that are not saturated by any factor.

Further use of SEM and inspection of several models can be useful and will be the basis of future investigations.

REFERENCES

ANASTASI, A., FULLER, J.L., SCOTT, J.P., SCHMITT, J.R., 1955. A factor analysis of the performance of dogs on certain learning tests. Zoologica-N Y 40(3):33-46.

BENTLER, P.M., WEEKS, D.G., 1980. Linear structural equations with latent variables. Psychometrika 45:289-308.

BOLLEN, K.A., 1989. Structural equations with latent variables. John Wiley & Sons, Inc., New York, USA.

CATTELL, R.B., 1952. Factor Analysis: An introduction and manual for the psychologist and social scientist. Harper Ed., New York, USA.

CHAMPNESS, K.A., 1996. Development of a breeding program for drug detector dogs - based on studies of a population of guide dogs. Degree Diss., University of Melbourne**,** Australia.

DIGMAN, J.M., 1990. Personality structure: emergence of the five-factor model. Annu. Rev. Psychol. 41:417-440.

DUNLAP, J.W., 1933. The organization of learning and other traits in chickens. Comp. Psychol. Monogr. Vol. 9, n. 4.

EVERITT, B.S., 1984. An introduction to latent variable models. Chapman and Hall Ed., New York, USA.

FULLER, J.L., THOMPSON, W.R. 1960. Behavior Genetics. Wiley Ed., New York, USA.

FURCHTGOTT, E., CURETON, E.E., 1964. Factor analysis of emotionality and conditioning in mice. Psychol. Rep. 15:787-794.

GODDARD, M.E., 1979. Development of a breeding programme for guide dogs. Degree Diss., University of Melbourne, Australia.

LOEHLIN, J.C., 2004. Latent variable models : an introduction to factor, path, and structural equation analysis. 4th rev. ed. Lawrence Erlbaum Associates, Mahwah, N.J., USA.

MC DONALD, R.P., MULAIK, S.A., 1979. Determinacy of common factors: A nontechnical review. Psychol. Bull. 86:297-306.

PEARL, J., 1997. The new challenge: from a century of statistics to an age of causation. Comput Sci Stat. 29:415-423.

PFAFFENBERGER, C.J., 1984. The new Knowledge of dog behavior. Howell Book House Ed., New York, USA.

ROYCE, J.R., POLEY, W., YEUDALL, L.T., 1973. Behavior genetic analysis of mouse emotionality: I. Factor Analysis. J. Comp. Physiol. 83(1): 36-47.

SERPELL, J.A., HSU, Y., 2001. Development and validation of a novel method for evaluating behavior and temperament in guide dogs. Appl. Anim. Behav. Sci. 72:347-364.

SHIPLEY, B., 2000. Cause and correlation in biology. A user's guide to path analysis, structural equations and causal inference. Cambridge University Press, Cambridge, UK.

SIMMEL, E.C., ELEFTHERIOU, B.E., 1977. Multivariate and behaviour genetic analysis of avoidance of complex visual stimuli and activity in recombinant inbred strains of mice. Behav. Genet. 7: 239-245.

SPSS., 1990. SPSS Reference Guide. Version 5.02. SPSS Inc. Chicago, IL, USA.

SVARTBERG, K., 2002. Shyness-boldness predicts performance in working dogs. Appl. Anim. Behav. Sci. 79:157-174.

SVARTBERG, K., 2005. A comparison of behaviour in test and in everyday life: evidence of three consistent boldness-related personality traits in dogs. Appl. Anim. Behav. Sci. 91:103-128.

SVARTBERG, K., FORKMAN, B., 2002. Personality traits in the domestic dog (*canis familiaris*). Appl. Anim.

Behav. Sci. 79:133-155.
SYSTAT®, 1999. Statistic I, Version 9,01. SPSS Inc., 233 South Wacker Drive, 11th Chicago, IL, USA.
VOLTINI, B., LEOTTA, R., 2003. Stime DFREML dell'ereditabilità di alcuni caratteri comportamentali in cani guida con un semplice animal model. Ann. Facoltà di Medicina Veterinaria di Pisa. 56: 229-241.
WILSSON, E., SUNDGREN, P.E., 1997. Behaviour test for eight week old puppies: Heritabilities for tested behaviour traits and its correspondence to adult behaviour. Appl. Anim. Behav. Sci. 58: 151-162.
WRIGHT, S., 1921. Correlation and causation. J. Agricultural Research 10:557-585.