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A Jury Test Methodology for the Assessment of User Rifle Trigger Tactile Preference

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Abstract — This paper presents a methodology to evaluate the preference of the user in relation to the trigger of a rifle. The selected approach is based on a Jury Test methodology which is a well known assessment method used in several fields, such as the subjective perception of acoustic noise or sound evaluation. In this case, the subjective test is applied to the tactile perception of the user to the stimuli of the rifle trigger, thus exploiting the possible means of interaction the human has with the object of interest. This approach is really important to define a complete user experience, helping to reach an innovative vision in the design and development of the product.

As the Jury Test collects subjective preferences given by the users, a methodology is presented to correlate objective indices to these subjective preferences. The correlation is performed considering different parameters of the rifle trigger, previously measured with a specific experimental campaign conducted on real rifles, using an elasticometer.

A correlation analysis is presented to find the optimal values of the objective metrics in order to maximise the subjective preference. In particular the highest values of the preferences towards the rifle trigger are correlated to the parameter of the trigger force and displacement. Best values have been found to be low force applied to the trigger and low trigger displacement. This method proves therefore to be efficient in correlating the parameters of this application case providing quantifiable feedback on the product in the context of a User-Centred Design.

Keywords — Jury Test, Rifle trigger, User-Centred Design, Metrics Correlation, Polynomial Fitting

I. INTRODUCTION

In the context of the product design and development there is a growing attention towards the needs and desires of the user. Therefore, a user-centered design approach has to be taken into account, while developing new products, especially if the user has a deep interaction with them, as it is the case of the rifle trigger. Benelli Armi S.p.A. shares this mission investing continuously in Research and Development to innovate its products. The Jury Test presented, focuses on the phase of the user testing of prototypes which is a crucial phase of the design process as it can be seen from Fig. 1



Fig. 1 - User-Centered Design [1]

The Jury Test analysis presented is part of a regional project (4USER project) coordinated by Benelli Armi S.p.A. This project exploits a design method based on the User Experience (UX) and aims to develop metrics derived from the correlation of experimental measurements and subjective tests. The main scope of this project is therefore to understand and anticipate the user needs and transform them into technical specifications [2].

The interaction with a rifle trigger while shooting is a complex task, involving the interaction of physical and mental processes immediately before, during, and immediately after the weapon fires [3].

The CREST report 753 reports a study focused on the development of neurophysiological measures to characterize expert and novice shooters. Different measure metrics influence the performance of the shooter: shot group precision, position quality, trigger control, breath control, steadiness, psychomotor measures, cognitive measures (scientific reasoning, basic rifle marksmanship knowledge), affective measures (state of anxiety, state of worry), situational measures etc. [3]. A USAARL report considers other objective parameters such as: measures of aim path, trigger pressure, shot accuracy, muzzle speed and gun movement [4].

The content of this paper presents a methodology to evaluate the interaction of the user with the rifle through a user-centered test according to objective measures of the rifle trigger assessed with an elasticometer. A Jury Test is used to evaluate the preference of the user towards the rifle trigger according to the tactile experience and involvement.

Moreover, a correlation analysis is carried out to evaluate which metrics are mostly influential for the user experience. It is in fact shown that perceptual-motor variables may be predictor of shooting performance [5].

This paper reports in Chapter II the definition of the parameters used in the test and in Chapter III the analysis of the results. Chapter IV presents the correlation between the most influential metrics extracted from the previous analysis. Chapter V reports the conclusions and the future developments of this methodology that could be applied to any field of UX application.

II. JURY TEST DEFINITION

Jury Test methodology is usually applied in sound quality analysis: a group of people rate sounds to determine the exact combination of metrics needed to fully understand the perception of a product's sound quality [6]. In our study, users are not asked to rate sound, while they are asked to rate tactile perception when using a rifle trigger. The metrics analysed are the user preference towards the trigger, the displacement and force given by the trigger and the shape of the curve, which represents the time-history of the trigger force in time.

The first step to perform a Jury Test is the selection of the Jury. It is shown that novice and expert skill performance can be differentiated thanks to sensor-based skill measures, as to say objective metrics [7]. In this application case, only mid-high expert users have been considered.

The ratings by the jury can be performed in many different ways. The three most popular test modalities are: Paired Comparison, Category Judgment and Semantic Differential. The Jury Test chosen for this use case is the Paired Comparison as this type of test is really simple for the users, especially if they are not accustomed to be jurors of a Jury Test, which is the case. In this type of test, the user experiences two different rifle triggers and has to indicate his preference towards one, answering a question with a single pair of answers: A or B.

While the user experiences the rifle trigger, an alarming sound is reproduced to make the user aware of the interaction and when it ends. Moreover there is 3 s pause between one interaction and the following of the same question.

In the Jury Test definition a total of 9 rifle trigger configurations are tested, for a duration of the interaction of 30 s per configuration.

An answer timeout is also settled so that, if the user does not respond to the question in the given time, the system goes to the following question recording for default the same answer given to the previous question.

According to the type chosen for this Jury Test, as it has been already discussed, the A-B Comparison mode is chosen. The option A-B replication is also included which allows to do a consistency check because the same configuration pair is presented more than once. A consistent juror should always pick the same choice as the preferred of the pair [6]. The option of A=B is not included as in this way the user is more encouraged to make a choice between A and B. Otherwise the option of equal would be the one preferred.

The Jury Test sequence is mainly composed of two sections: training session and main session. The training

session can be used to teach the jurors how to use the software and also prepare them for the upcoming questions [8]. In the definition phase of the test it is useful to discuss if and how many questions can be used for the training phase, according also to the overall duration of the test. In the test sequence it is possible to add different items such as messages or questions which may help to correlate sound preferences with the jurors' age, lifestyle, experience and opinions [8]. In this application case only a notification message is used to inform the users about the ending of the training session and the beginning of the main session.

Errore. L'origine riferimento non è stata trovata. collects all the main parameters of the Jury Test applied in this use case.

TABLE I. JURY TEST PARAMETERS

Parameter name	Parameter Value
Number of trigger configurations	9
Duration of each interaction [s]	30
Answer Timeout [s]	10
Allow Backward Navigation	No
Type	A-B Comparison
Question	Which rifle trigger do you prefer?
Time interval between A&B [s]	3
Perform A-B Replication	Yes
Allow A=B	No
Total duration of the test [min]	39:36
Total number of questions	72
Execution Mode	Individual

III. JURY TEST RESULTS ANALYSIS

The test is performed by 33 users who have medium and high experience in using rifles. The analysis of the results is performed by the software Simcenter Testlab from Siemens. Different analysis and filter operations are performed on the results obtained.

A. Consistency And Concordance

Both Consistency and Concordance Index are computed to ensure high quality correlation.

These indices range from 0 to 1 and their meaning is the following [3]:

- Consistency that is checked in two ways:
 - A-B Consistency: this value evaluates if the juror makes always the same choice when presented the same two configurations. This index can therefore be computed only if the option of A-B Replication is active. If the value is close to 0 it can mean that the juror may be confused or not paying attention;
 - Circular Triad Consistency: this index ensures that jurors are consistent in their hierarchy of ratings. For example, if a juror rates Configuration 1 higher than Configuration 2, and rates Configuration 2 higher than Configuration 3, then the juror should rate Configuration 1 higher than Configuration 3.
- Concordance that checks whether an individual juror follows the group with his responses. If a juror does not follow the pack with his responses, he is given a low concordance score. This may be due to a difference in

demographic therefore a filter on the Concordance value can be applied to remove the users whose Concordance value is low.

Fig. 2 presents an example of a Consistency-Concordance plot. The jurors in green are both concordant and consistent while the ones in red should probably be excluded from the analysis.



Fig. 2 Consistency-Concordance plot example [6]

The results obtained in Testlab are then exported in Excel where there are:

- Answers A-B Comparison: the results about the indices of Concordance, Circular Triad Consistency and AB Consistency for each user. Moreover, there is the index of Combined Consistency which combines the two previous metrics into one, calculated as [8]:

$$\text{CombinedConsistency} = (w * \text{ABConsistency}) + (1-w) * \text{CircularTriadConsistency} \quad (1)$$

The weights w are by default equal (this is the option selected for the use case) even though this can be changed in the Jury Test configuration.

- Analysis A-B Comparison: preference values obtained from the A-B Comparison analysis.

Errore. L'origine riferimento non è stata trovata. reports the values of the Preference obtained evaluating the answers of the 33 users for each of the 9 configurations tested. The value of the force applied to the trigger and its displacement is also measured using an elasticometer. Those parameters represent the objective metrics, related to the trigger design.

TABLE II. CONFIGURATIONS TESTED AND RESULTING PREFERENCES

Run	Force [N]	Displacement [mm]	Preference
Run 1	Mean	Min	372
Run 2	Max	Mean	207
Run 3	Max	Max	120
Run 4	Min	Mean	346
Run 5	Mean	Mean	335
Run 6	Max	Min	174
Run 7	Mean	Max	241
Run 8	Min	Min	374
Run 9	Min	Mean	207

From this table it is clear that the preferred rifle triggers are the number 1, 4, 5, 8 with low levels of Force and Displacement.

For each configuration tested the mean value of the levels obtained from the analysis A-B comparison is calculated and reported in Fig. 3 along with the standard deviation. Highest mean rating values are the ones of configuration 1, 4, 5, 8. In particular, configuration 1 and 8 report also low standard deviation values.

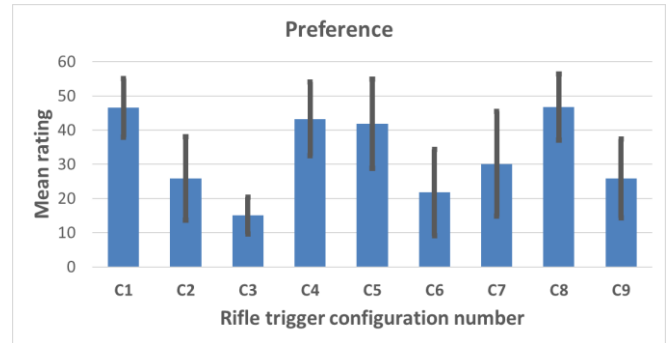


Fig. 3 Preference values and mean rating

B. Results Filtering the Concordance

As some values of Concordance are low, a filter is applied removing users with Concordance below 0.5. The Consistency and Concordance values are recalculated according to the new panel of users which is 20 users (instead of the 33 total previous users). Fig. 4 and Fig. 5 show the Consistency-Concordance Plot without and with the filter, respectively.

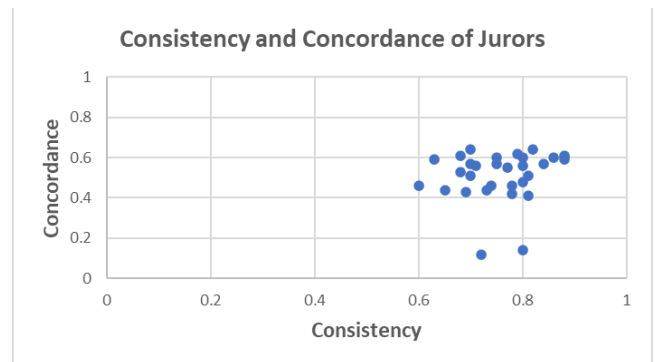


Fig. 4 Consistency vs Concordance plot - No filter on Concordance

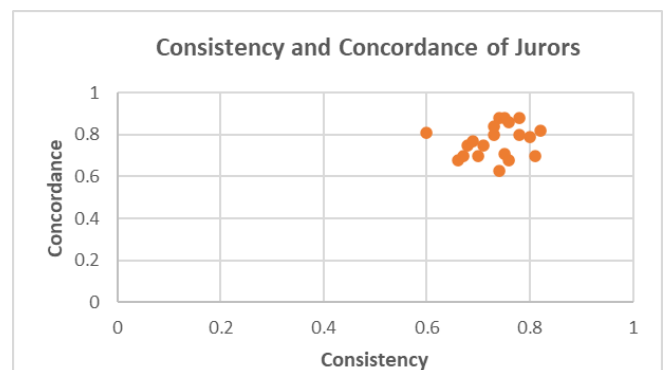


Fig. 5 Consistency vs Concordance plot - 0.5 filter on Concordance

The value of preference is then calculated on the new results with 0.5 filter on Concordance and reported in **Errore. L'origine riferimento non è stata trovata.** Apart from minor differences, the Preference level result the same, confirming the preferred configurations 1, 4, 5, 8.

TABLE I CONFIGURATIONS TESTED AND RESULTING PREFERENCES – 0.5 filter on Concordance

Run	Force [N]	Displacement [mm]	Preference
Run 1	Mean	Min	240
Run 2	Max	Mean	106
Run 3	Max	Max	52
Run 4	Min	Mean	223
Run 5	Mean	Mean	205
Run 6	Max	Min	104
Run 7	Mean	Max	144
Run 8	Min	Min	256
Run 9	Min	Mean	110

Fig. 6 represents the obtained values for the preference where the configurations 1, 4, 5, 8 are still the ones preferred. The parameters of Force and Displacement used for the test are the same reported in **Errore. L'origine riferimento non è stata trovata.** The standard deviation is also computed and plotted considering the mean value calculated on the values of preference obtained for each configuration.

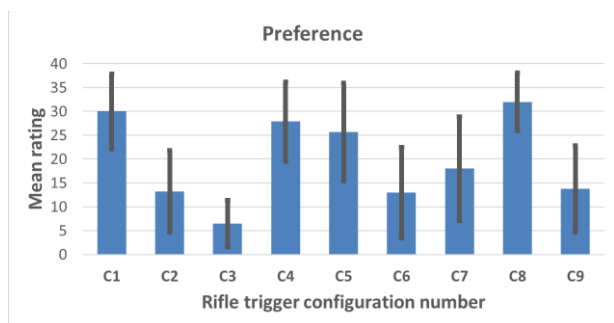


Fig. 6 Preference values with filter on Concordance

IV. CORRELATION OF THE OBJECTIVE METRICS TO THE SUBJECTIVE RESULTS

The main purpose of this analysis is to find the best combination of objective metrics to be correlated with the subjective preference. Different parameters can be taken into account to evaluate the performance of a user with a rifle trigger. For example, the report CRESST 755 reports the following objective measures: breath location, breath duration, shot-percent breath, trigger duration [7].

For the use case presented, the objective metrics chosen for the correlation are the Force given to the trigger and Displacement of the trigger, which values were previously measured for each rifle trigger configuration.

A. Polynomial Fitting Model

A Polynomial Fitting is applied considering the three metrics chosen, in order to obtain a model that can fit the values of Force, Displacement and preference. Once this model is obtained it can be possible to estimate the value of preference given arbitrary values of Force and Displacement. The Force and Displacement analysed were three: minimum, mean and maximum level.

Fig. 7 reports the Preference values obtained from the Jury Test analysis presented, considering the filter on Concordance. These preference values, identifiable also with the colorbar, are plotted against the Displacement and Force metrics, for which three levels of value intensity are considered.

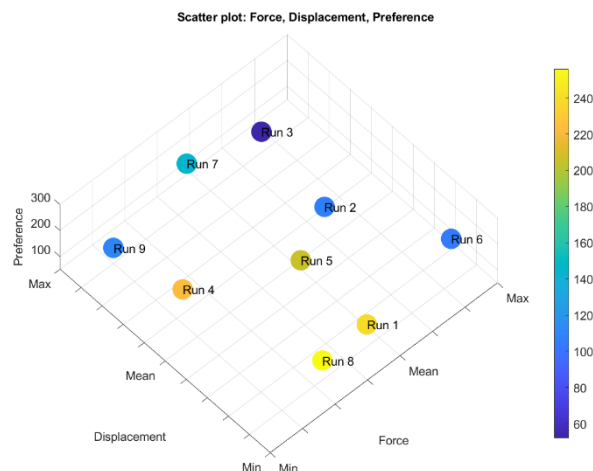


Fig. 7 Scatter plot of Preference values vs Displacement and Force metrics

Different polynomial fitting types are computed and the value of the Rsquare is calculated. As there is only a set of 9 combinations tested, it is possible to reach a maximum of second order polynomial fitting. TABLE II reports the polynomial models tested and the resulting equation and Rsquare value. The best fitting model tested results the Poly22 with Rsquare 0.93.

TABLE II POLYNOMIAL FITTING MODELS

Fit Type	Equation	Rsquare
Poly11	$\text{fitresult}(x,y) = 160 - 44.63*x - 47.36 *y$	0.8445
Poly12	$\text{fitresult}(x,y) = 167.1 - 45.6*x - 46.76*y + 17.77 *x*y - 8.878*y^2$	0.8837
Poly21	$\text{fitresult}(x,y) = 179.3 - 41.35*x - 46.54*y - 21.99*x^2 + 6.651 *x*y$	0.9244
Poly22	$\text{fitresult}(x,y) = 187.9 - 41.82*x - 46.63*y - 22.26*x^2 + 9.548*x*y - 9.649 *y^2$	0.9317

The fitting surface applied to the dataset using Poly22 model is reported in Fig. 8.

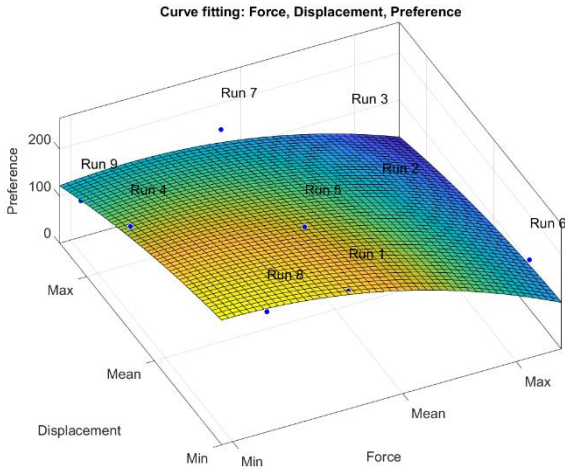


Fig. 8 Model fitting: Force, Displacement, Preference

B. Metrics Optimal Values

Once defined the model fit, the optimal value for the objective metrics of Force and Displacement is found. Low values of both force and displacement allow to have high preference values. In particular, the optimal value found corresponds to a preference value of 256 (Fig. 9).

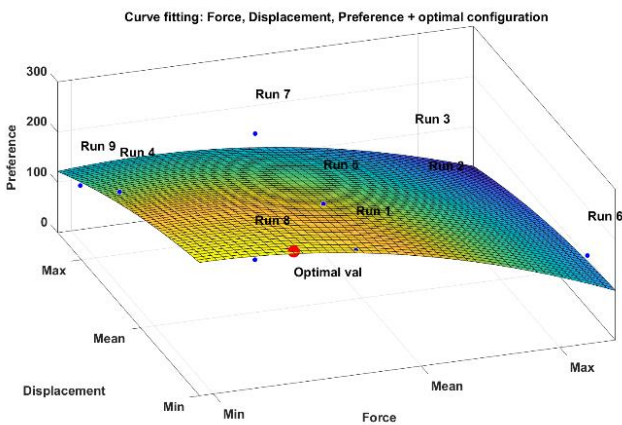


Fig. 9 Metrics values for Optimal configuration

V. CONCLUSIONS

Rifle marksmanship is a complex skill that is influenced by numerous parameters, such as the perceptual-motor, cognitive, and affective variables.

The measurement methodology proposed in this paper is based on a user-experience approach, in order to evaluate his/her preference on the tactile interaction with a rifle trigger using the well-known procedure based on the Jury Test.

From our experiments, the best configurations according to the user preferences are the ones based on low Force and Displacement (1, 4, 5, 8) while configuration 3 is the worst, as it presents high levels of both the objective metrics.

The correlation analysis combined with the use of a polynomial fitting model demonstrates that the highest value of the preference towards the rifle trigger is correlated to low values of both the parameters: trigger Force and Displacement.

Other correlation parameters could be taken into account for future developments of this work, opening therefore the path towards an exhaustive user-centred analysis of the rifle preference.

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