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Application of annotated paraconsistent logic to surveys conducted of self-administered questionnaires containing redundant questions

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Analysis and modelling

ABSTRACT

Purpose: Opinion polls and evaluation questionnaires are routinely applied as a means to gauge the most diverse topics and often result inconsistent, mainly because, as they are directed to the public in general and not for specialists only, they must perforce employ quite straightforward, easy to understand, questions, which are vague by their own nature and allow too much for interpretation (i. e. present much cognitive imprecision) on the part of the surveyee.
Design/methodology/approach: On one hand, they are cheap to conduct, and are the most widely known and accepted way to measure all kinds of otherwise intangible things as preference, satisfaction and happiness. On the other hand, it is well established that the wording of the questions, the order in which they are asked and the number and form of alternative answers offered can influence results of such surveys, so much that, on some issues, question wording can result in quite pronounced differences between surveys.
Findings: This problem has been recognized almost from the time the questionnaire was invented by Sir Francis Galton (in the first decade of the 20th century), and numerous processes and techniques have been developed since then, always aiming at achieving more reproductible results and eliminating all kinds of biases.
Research limitations/implications: In the present communcation we envision a novel survey instrument, designed to be analyzed by means of annotated paraconsistent logic techniques, which allows for both the detection of contradictions and inconsistencies on the part of the respondent, as well as for the continuous improvement of the adequacy of the instrument in itself. We also present, as a proof-of-concept, the application of the said methodology to two car dealer customer satisfaction evaluation surveys, and an in-depth analysis of the results it has yielded.
Originality/value: In the present communication, previously applied questionnaires, designed to gauge car dealer customer satisfaction, both on new vehicle acquisition and on servicing, are analyzed by means of this novel method.
Keywords: Annotated paraconsistent logics; Para-Analyzer algorithm; Redundancy; Opinion questionnaire

1. Introduction

Opinion polls and evaluation questionnaires are routinely applied as a means to gauge the most diverse topics and often result inconsistent, mainly because, as they are directed to the public in general and not for specialists only, they must perforce employ quite straightforward, easy to understand, questions, which are vague by their own nature and allow too much for interpretation (*i. e.* present much cognitive imprecision) on the part of the surveyee. Some questionnaires, however, allow one to

collect the selfsame information from diverse questions, because they contain some degree of redundancy. This kind of questionnaires is adequate to be analyzed by means of Annotated Paraconstent Logic, by evaluating the positive or negative degrees-of-evidence, and the overall result on the answers provided. Even some already existent surveys can be analyzed in this way, when the questionnaires employed already present this type of redundancy.

In the present communication, previously applied questionnaires, designed to gauge car dealer customer satisfaction, both on new vehicle acquisition and on servicing, are analyzed by means of this novel method [1-3].

1.1. Annotated Paraconsistent Logic (APL)

APL (Da Silva Filho, 2007) defines the degree-of-evidence (a type of annotation, in fact, a grading) of a given proposition as a real number comprised between 0 and 1. Such degree of evidence is commonly obtained by comparing the opinions of two different specialists. Its main difference from classical logic or from the fuzzy logics lies in the employment of a second gauging of the same proposition in order to evaluate it also by means of the negative degree-of-evidence. Of course, the positive or negative degrees-of-evidence might be redefined, as convenient, to other types of belief (as, for instance, possible and impossible, or favorable or unfavorable…).

Hence, from the point-of-view of APL any given logical state can be found by means of two annotation values (μ_1 and μ_2), of which μ_1 represents the positive and μ_2 the negative degree-of-evidence associated with a given proposition (De Carvalho, 2006). The result of a paraconsistent logic analysis is twofold: a value and a verdict. The verdict may be ***conclusive*** (***viable*** or ***not-viable***) or ***inconclusive,*** and, at the same time, either ***coherent*** or ***incoherent.*** The sum of μ_1 and μ_2 is unity when complete coherence is observed and two or zero when there is no coherence at all. To render these values into a more usual scale, it is conventional to subtract one from this sum, as a scaling factor (*i. e.* to cause it to vary between –1 and +1). In other words, if the sum of the annotation values doesn´t result in unity, this indicates that they have some degree of incoherence, and thus, the degree-of-contradiction (G_c) is defined as the value of the difference between the sum of μ_1 and μ_2 (some incoherence) and 1 (total coherence).

As μ_1 represents the positive and μ_2 the negative degrees-of-evidence, the full *viable-state* (true) occurs when μ_1 is evaluated as 1 and μ_2 is evaluated as 0, and thus, the degree-of-certainty (H_c) is defined as the value of the difference between μ_1 and μ_2. In an ideal world, if the value of μ_1 is greater than μ_2, the result can be considered viable. In reality one must consider that things are less clean-cut and it becomes necessary to define acceptability ranges to be able to employ the APL effectively. To reach a verdict, one must have either $-r_{LG} \leq G_c \leq r_{LG}$, (where r_{LG} is the degree-of-contradiction requirement-level) meaning ***coherent***, or the reverse, meaning ***incoherent***. In a similar way, one must have $H_c \geq r_{LH}$, (where r_{LH} is the degree-of-certainity requirement-level), meaning ***viable*** (or "true") or $H_c \leq -r_{LH}$, meaning ***not-viable*** (or "false"), or else $-r_{LH} \leq H_c \leq r_{LH}$ meaning ***inconclusive***. For the purposes of the present work, we have adopted $r_{LG}=r_{LH}=r_L$, for the sake of simplicity.

2. Aplication of the method

Our approach at analyzing questionnaires has the central novel feature that, instead of somehow acquiring two samples for each individual response (which, in fact, is impossible) we adopted a statistical procedure to obtain the values of μ_1 and μ_2 from questionnaires containing both Boolean (or Yes/No) questions and gradings in its structure. This method was applied to questionnaires returned by the customers of a car-dealer in São Roque city, comprising 249 customers who bought a new car (**Q1**) and 49 customers who had used the car-dealer's car maintenance service (**Q2**).

2.1. Identification of the information subgroups

Within **Q1**, three subgroups of information provided were identified: satisfaction with the sales-person (**S1**), satisfaction with delivery (**S2**) and satisfaction with the car-dealer (**S3**). Within **Q2**, also three subgroups of information provided were found: satisfaction with the technical-consultant (**S1**), satisfaction with the servicing of the vehicle (**S2**) and satisfaction with the car-dealer (**S3**).

The questionnaires contained two kinds of questions: one that was composed of yes/no questions and the other, comprising questions to be answered as a 0 to 10 grading. In each questionnaire, the questions were grouped by us into information subgroups comprising some yes/no questions (F1, ..., Fm) and one grading question (Sn), so that each Sn is associated to various Fm questions. Here lies the prerequisite redundancy required by the APL analysis. The average value of each Sn was considered as μ_1n and μ_2n was constructed from averages over the appropriated the yes/no questions.

Both questionnaires are presented in full in Table 1 below (observe that the original questionnaires were applied in the Portuguese language, and that our rendering of the questions in English aims at preserving the ambiguities and awkwardnesses that already exist in the original Portuguese version of them, and that are fundamental for the understanding of the results of our analyses).

2.2. Evaluation of the values of μ_1

As every single responder's individual questionnaire has the same statistical weight, the positive degrees-of-evidence (μ_1) for each question subgroup were evaluated as the simple average of the grades provided for all the responses. As not all questions were always answered, only the questions effectively answered, in each case, were considered for the calculation of the averages.

Table 1.
The Customer Satisfaction Questionnaires

(Q1) - New car acquisition	
(S1) Satisfaction with the sales-person	Grading
F1) Were your phone calls answered promptly and cordially?	Yes/No
F6) Was the sales-person courteous and professional?	Yes/No
F7) Was the sales-person clearly identified and properly attired?	Yes/No
F8) Did the sales-person spend enough time to you?	Yes/No
F9) Has the sales-person helped you in the choice of a suitable car?	Yes/No
F10) Was the sales-person knowledgeable about our brand line of products?	Yes/No
F11) Was the sales-person knowledgeable about other brands lines of products?	Yes/No
F12) Did the sales-person inform you about the available additional products and services?	Yes/No
F13) The car model was not available. Did the sales-person provide you a time-frame for availability?	Yes/No
F14) Was the vehicle delivered on time?	Yes/No
F15) Was the delivery a personally pleasing experience?	Yes/No
F16) Was the sales-person personally present at delivery?	Yes/No
(S2) – Satisfaction with the process of delivery of the new vehicle	Grading
F13)The car model was not available. Did the sales-person provide you a time-frame for availability?	Yes/No
F14)Was the vehicle delivered on time?	Yes/No
F15)Was the delivery a pleasing personal experience?	Yes/No
F16)Was the sales-person personally present at delivery?	Yes/No
(S3) - Satisfaction with the car-dealer	Grading
F1)Were your phone calls answered promptly and cordially?	Yes/No
F2)Were our business-hours convenient to you?	Yes/No
F3)Were the various business departments clearly identified?	Yes/No
F4)Were the facilities comfortable and pleasant?	Yes/No
F5)Were you received promptly?	Yes/No
F6)Was the sales-person courteous and professional?	Yes/No
F7)Was the sales-person clearly identified and properly attired?	Yes/No
F8)Did the sales-person spend enough time with you?	Yes/No
F9)Has the sales-person helped you in the choice of a suitable car?	Yes/No
F10)Was the sales-person knowledgeable about our brand line of products?	Yes/No
F11)Was the sales-person knowledgeable about other brands lines of products?	Yes/No
F12)Did the sales-person inform you about the available additional products and services?	Yes/No
F13)The car model was not available. Did the sales-person provide you a time-frame for availability?	Yes/No
F14)Was the vehicle delivered on time?	Yes/No
F15)Was the delivery a pleasing personal experience?	Yes/No
F16)Was the sales-person personally present at delivery?	Yes/No
F17)Were you introduced to the someone in the service and in the parts departments?	Yes/No
F18)Were the warranty and the first special revision explained to you?	Yes/No
F19)Were the owner's manual and the vehicle's maintenance schedule explained to you?	Yes/No
F20)Were all the vehicle's characteristics and its operating controls explained to you?	Yes/No
F21)Were you told about our Customer Service Center?	Yes/No
F22)Was the Road Service explained to you?	Yes/No
F23)When you received your new vehicle, was it problem free?	Yes/No
F24)Has the car-dealer contacted you within five working days regarding your satisfaction?	Yes/No
F26)Do you find the terms of payment satisfactory?	Yes/No
(Q2) – Car maintenance services	
(S1) – Satisfaction with the technical-consultant	Grading
F3)Was the technical-consultant courteous and professional?	Yes/No
F4)Is the service department a clean and pleasing environment?	Yes/No
F5)Was the technical-consultant knowledgeable about the required servicing?	Yes/No

	F6)Were you offered an interin replacement means of transportation?	Yes/No
	F7)Did the technical-consultant manage the vehicle inspection?	Yes/No
	F8)Was the technical-consultant patient and attentive?	Yes/No
	F9)Did the technical-consultant make a clear record of your requests?	Yes/No
	F10)Did the technical-consultant offer a preliminary analysis of the issue at hand?	Yes/No
	F11)Did the technical-consultant inform you about the services required?	Yes/No
	F12)Did the technical-consultant provide you with a deadline for the return of the vehicle?	Yes/No
	F13)Was the vehicle ready at the deadline?	Yes/No
	F14)Were you informed in advance that the vehicle was not ready?	Yes/No
	F15)Did the technical-consultant consult you before ordering any additional servicing?	Yes/No
	F16)Were the services performed explained to you?	Yes/No
(S2) – Satisfaction with the servicing of the vehicle		Grading
	F17)Was the vehicle clean on receipt?	Yes/No
	F18)Were all the components of the dashboard firmly in place and well adjusted?	Yes/No
	F19)Did the first attempt at servicing already resolve the issue?	Yes/No
	F20)Was the issue not diagnosed?	Yes/No
	F21)Did the repair not correct the issue?	Yes/No
	F22)Were the required parts in-stock at the car-dealer's?	Yes/No
	F23)If not, were the unavailable part(s) obtained in an appropriate time-frame?	Yes/No
	F24)Did you received any documentation of the services performed?	Yes/No
	F25)Has the car-dealer contacted you within five working days regarding your satisfaction?	Yes/No
(S3) -Satisfaction with the car-dealer		Grading
	F1)Were our business-hours convenient to you?	Yes/No
	F2)Did you succeed at scheduling for servicing / preventive maintenance?	Yes/No
	F3)Was the technical-consultant courteous and professional?	Yes/No
	F4)Is the service department a clean and pleasing environment?	Yes/No
	F5)Was the technical-consultant knowledgeable about the required servicing?	Yes/No
	F6)Were you offered an interim replacement means of transportation?	Yes/No
	F7)Did the technical-consultant manage the vehicle inspection?	Yes/No
	F8)Was the technical-consultant patient and attentive?	Yes/No
	F9)Did the technical-consultant make a clear record of your requests?	Yes/No
	F10)Did the technical-consultant offer a preliminary analysis of the issue at hand?	Yes/No
	F11)Did the technical-consultant inform you about the services required?	Yes/No
	F12)Did the technical-consultant provide you with a deadline for the return of the vehicle?	Yes/No
	F13)Was the vehicle ready at the deadline?	Yes/No
	F14)Were you informed in advance that the vehicle was not ready?	Yes/No
	F15)Did the technical-consultant consult you before ordering any additional servicing?	Yes/No
	F16)Were the services performed explained to you?	Yes/No
	F17)Was the vehicle clean on receipt?	Yes/No
	F18)Were all the components of the dashboard firmly in place and well adjusted?	Yes/No
	F19)Did the first attempt at servicing already resolve the issue?	Yes/No
	F20)Was the issue not diagnosed?	Yes/No
	F21)Did the repair not correct the issue?	Yes/No
	F22)Were the required parts in-stock at the car-dealer's?	Yes/No
	F23)If not, were the unavailable part(s) obtained in an appropriate time-frame?	Yes/No
	F24)Did you received any documentation of the services performed?	Yes/No
	F25)Has the car-dealer contacted you within five working days regarding your satisfaction?	Yes/No

2.3. Evaluation of the values of μ_2

The negative degrees-of-evidence (μ_2) were evaluated from the yes/no questions, as follows: Since μ_2 gauges the negative factor (by definition) and the actual questions were posed in a positive fashion we assigned the value of 1 to a "no" answer and of 0 to a "yes" answer. To obtain the final result, for each question, the simple average over all the answers for that specific question was calculated, and assigned to a μ_2 value. This also means that various values of μ_2 were obtained for each single value of μ_1. Again, as not all questions were always answered, only the questions effectively answered were considered for the averages. Having on hand values for both μ_1 and μ_2, a first run of these data through the Para-Analyzer Algorithm (PAA, Da Costa, 1999) yielded not always consistent preliminary results, because some of the questions were in fact formulated in a negative way. Hence, for these questions only we have adopted the complementary value to that initially used (*i. e.*: 1 = "yes", 0 = "no"), thus removing the observed inconsistency. This procedure will henceforward be described as "evidence-reversion". We have adopted, throughout the present work, 0.55 as the standard requirement-level (r_L).

3. Results

3.1. Q1-S1 New car acquisition questionnaire subgroup satisfaction with the sales-person

As described in the previous section, initially, the average values μ_1 and μ_2 of Q1-S1 were calculated over all returned questionnaires. These data were then analyzed with the PAA (Table 2), resulting in the identification of one lone inconclusive response at the question S1-F13 ('The car model was not available. Did the sales-person provide you a time-frame for availability?'), and a careful inspection of this question indicated that evidence-reversion was warranted here. After this correction, reapplication of the PAA yielded an all-viable result (Table 3).

Table 2.
Raw PAA results for Q1-S1

		Results				Conclusions
Group	Question	μ_1	μ_2	Hc	Gc	Verdict
S1	F1	0,9	0,0	0,9	-0,1	VIABLE
S1	F6	0,9	0,0	0,9	-0,1	VIABLE
S1	F7	0,9	0,0	0,9	-0,1	VIABLE
S1	F8	0,9	0,0	0,9	-0,1	VIABLE
S1	F9	0,9	0,0	0,9	-0,1	VIABLE
S1	F10	0,9	0,0	0,9	-0,1	VIABLE
S1	F11	0,9	0,1	0,8	0,0	VIABLE
S1	F12	0,9	0,0	0,8	-0,1	VIABLE
S1	F13	0,9	0,9	0,0	0,8	INCONCLUSIVE
S1	F14	0,9	0,1	0,8	0,0	VIABLE
S1	F15	0,9	0,2	0,7	0,0	VIABLE
S1	F16	0,9	0,0	0,9	-0,1	VIABLE
Average		0,8	0,1	0,8	0,0	VIABLE

Table 3.
Refined PAA results for Q1-S1

		Results				Conclusions
Group	Question	μ_1	μ_2	Hc	Gc	Verdict
S1	F1	0.9	0.0	0.9	-0.1	VIABLE
S1	F6	0.9	0.0	0.9	-0.1	VIABLE
S1	F7	0.9	0.0	0.9	-0.1	VIABLE
S1	F8	0.9	0.0	0.9	-0.1	VIABLE
S1	F9	0.9	0.0	0.9	-0.1	VIABLE
S1	F10	0.9	0.0	0.9	-0.1	VIABLE
S1	F11	0.9	0.1	0.8	0.0	VIABLE
S1	F12	0.9	0.0	0.8	-0.1	VIABLE
S1	F13	0.9	0.1	0.8	0.0	VIABLE
S1	F14	0.9	0.1	0.8	0.0	VIABLE
S1	F15	0.9	0.2	0.7	0.0	VIABLE
S1	F16	0.9	0.0	0.9	-0.1	VIABLE
Average		0.9	0.1	0.9	-0.07	VIABLE

3.2. Q1-S2 New car acquisition questionnaire subgroup satisfaction with the process of delivery of the new vehicle

For all the next subgroups the selfsame method was applied. The averages of μ_1 and μ_2 of Q1-S2 were calculated over all returned questionnaires and then were analyzed with the PAA to evaluate the viability of each individual question. Also here (Table 4), an all-viable result was obtained.

Table 4.
PAA results for Q1-S2

		Results				Conclusions
Group	Question	μ_1	μ_2	Hc	Gc	Verdict
S2	F13	0,8	0,1	0,7	0,0	VIABLE
S2	F14	0,8	0,1	0,8	-0,1	VIABLE
S2	F15	0,8	0,2	0,7	0,0	VIABLE
S2	F16	0,8	0,0	0,8	-0,1	VIABLE
Average		0,8	0,1	0,7	-0,1	VIABLE

3.3. Q1-S3 New car acquisition questionnaire subgroup satisfaction with the car-dealer

In the evaluation of the car-dealer, the grades assigned to the item '*satisfaction with the car-dealer*' were taken to represent the favorable evidence (μ_1), while the unfavorable evidence (μ_2) was calculated over all the yes/no questions in the questionnaire including those that related only to Q1-S3, as well as those already deemed to also pertain to either Q1-S1 or Q1-S2, because this was the main target of the questionnaire **Q1**. Once again (Table 5), an all-viable result was obtained.

Table 5.
PAA results for Q1-S3

		Results			Conclusions	
Group	Question	μ_1	μ_2	Hc	Gc	Verdict
S3	F1	0,8	0,0	0,8	-0,1	VIABLE
S3	F2	0,8	0,0	0,8	-0,2	VIABLE
S3	F3	0,8	0,0	0,8	-0,2	VIABLE
S3	F4	0,8	0,0	0,8	-0,1	VIABLE
S3	F5	0,8	0,0	0,8	-0,2	VIABLE
S3	F6	0,8	0,0	0,8	-0,2	VIABLE
S3	F7	0,8	0,0	0,8	-0,2	VIABLE
S3	F8	0,8	0,0	0,8	-0,2	VIABLE
S3	F9	0,8	0,0	0,8	-0,1	VIABLE
S3	F10	0,8	0,0	0,8	-0,2	VIABLE
S3	F11	0,8	0,1	0,7	-0,1	VIABLE
S3	F12	0,8	0,0	0,8	-0,1	VIABLE
S3	F13	0,8	0,1	0,7	-0,1	VIABLE
S3	F14	0,8	0,1	0,8	-0,1	VIABLE
S3	F15	0,8	0,2	0,7	0,0	VIABLE
S3	F16	0,8	0,0	0,8	-0,1	VIABLE
S3	F17	0,8	0,2	0,7	0,0	VIABLE
S3	F18	0,8	0,0	0,8	-0,2	VIABLE
S3	F19	0,8	0,0	0,8	-0,2	VIABLE
S3	F20	0,8	0,0	0,8	-0,2	VIABLE
S3	F21	0,8	0,0	0,8	-0,1	VIABLE
S3	F22	0,8	0,0	0,8	-0,1	VIABLE
S3	F23	0,8	0,1	0,8	-0,1	VIABLE
S3	F24	0,8	0,1	0,7	-0,1	VIABLE
S3	F25	0,8	0,2	0,6	0,0	VIABLE
Average		0,8	0,1	0,8	-0,1	VIABLE

3.4. Q2-S1 Car-dealer maintenance service questionnaire, subgroup satisfaction with the technical consultant

The second questionnaire studied herein aims to evaluate the perceived quality of the car-dealer's after-selling maintenance services. The method employed here is the same already applied to the first questionnaire. The average values of μ_1 and μ_2 of **Q2** were calculated over all returned questionnaires and then were analyzed with the PAA, for every one of the subgroups considered. Table 6, below, presents the results from the analysis of the subgroup Q2-S1.

The PAA results for the subgroup Q2-S1 (Table 6) unveiled two questions deemed inconclusive, so a closer look at these questions is warranted: (i) question F7 ('*Did the technical-consultant manage the vehicle inspection?*') is formulated clearly, but yielded a degree-of-certainty value (0.5) very close to that of the requirement-level (0.55). This result unveiled a truly unanswerable question, because, in fact, the car-dealer does not perform the vehicular inspection in the presence of customer (this information was provided us by the car-dealer's owner on direct questioning), so the customer has no way to answer truthfully to this question and either does not answer or enters his/hers wild guess on the matter. Of course, such a question ought not to be part of the questionnaire, and shall be removed from its revised version; (ii) question F14 ('*Were you informed in advance that the vehicle was not ready?*') is improperly formulated, since the questionnaire was applied to all customers that used the maintenance service, and not just for those customers who experienced delays in vehicle return, and the PAA detected it, awarding inconclusive status to the question. This question also should be reformulated or removed from the questionnaire, since it is intended to be applicable to every customer.

Table 6.
PAA results for Q2-S1

		Results			Conclusions	
Group	Question	μ_1	μ_2	Hc	Gc	Verdict
S1	F3	0,8	0,0	0,8	-0,2	VIABLE
S1	F4	0,8	0,0	0,8	-0,2	VIABLE
S1	F5	0,8	0,0	0,7	-0,2	VIABLE
S1	F6	0,8	0,2	0,6	0,0	VIABLE
S1	F7	0,8	0,2	0,5	0,0	INCONCLUSIVE
S1	F8	0,8	0,0	0,8	-0,2	VIABLE
S1	F9	0,8	0,0	0,7	-0,2	VIABLE
S1	F10	0,8	0,0	0,7	-0,2	VIABLE
S1	F11	0,8	0,1	0,7	-0,2	VIABLE
S1	F12	0,8	0,1	0,7	-0,2	VIABLE
S1	F13	0,8	0,1	0,7	-0,2	VIABLE
S1	F14	0,8	0,8	0,0	0,6	INCONCLUSIVE
S1	F15	0,8	0,1	0,7	-0,1	VIABLE
S1	F16	0,8	0,1	0,7	-0,2	VIABLE
Average		0,8	0,1	0,7	-0,1	VIABLE

3.5. Q2-S2 - Car-dealer maintenance service questionnaire, subgroup satisfaction with the servicing of the vehicle

Three inconclusive results (Table 7) were unveiled in the PAA results for the subgroup Q2-S2: (i) in the question '*Did the repair not correct the issue?*' (F21), the presence of the word 'not' may give the impression that the allocation of 1 to answer 'No' is mistaken but, in fact, on evidence-reversion of the values, the resulting degree-of-contradiction (G_c) actually increases from 0.1 to 0.4, tending to inconsistency. Hence, this question actually returned inconclusive responses, probably because it is too subjective. (ii) questions F22 and F23 ('*Were the required parts in-stock at the car-dealer's? / If not, were the unavailable part(s) obtained in an appropriate time-frame?*'), are linked to each other, and deal with subjects not always made known to the customer. A part may not exist in stock but, when it is obtained fast enough, the customer is not informed about it. So here again unanswerable questions were found, that need to be reformulated or removed to allow a better assessment.

Table 7.
PAA results for Q2-S2

		Results				Conclusions
Group	Question	μ_1	μ_2	Hc	Gc	Verdict
S2	F17	0,8	0,2	0,6	-0,1	VIABLE
S2	F18	0,8	0,1	0,7	-0,2	VIABLE
S2	F19	0,8	0,2	0,6	-0,1	VIABLE
S2	F20	0,8	0,2	0,6	-0,1	VIABLE
S2	F21	0,8	0,4	0,4	0,1	INCONCLUSIVE
S2	F22	0,8	0,4	0,3	0,2	INCONCLUSIVE
S2	F23	0,8	0,3	0,5	0,0	INCONCLUSIVE
S2	F24	0,8	0,1	0,7	-0,1	VIABLE
S2	F25	0,8	0,1	0,7	-0,2	VIABLE
Average		0,8	0,2	0,6	-0,1	INCONCLUSIVE

3.6. Q2-S3 - Car-dealer maintenance service questionnaire, subgroup satisfaction with the car-dealer

For the analysis of the group Q2-S3, the grades assigned to the item '*satisfaction with the car-dealer*', were taken to represent μ_1, while μ_2 was calculated over all the yes/no questions in the questionnaire including those that related only to Q2-S3, as well as those already deemed to also pertain to either Q2-S1 or Q2-S2, because this was the main target of the questionnaire **Q2**, in line with our procedure for questionnaire **Q1**. Even the questions that were deemed inconclusive within the other subgroups were considered again here, because they now were being compared to the μ_1 specific to this subgroup (Table 8). While the overall result was viable, the same five inconclusive questions were detected, as expected.

4. Conclusions

The analysis of both questionnaires using APL, with the help of the PAA indicated that: (i) all questions were deemed coherent, in both questionnaires; (ii) those questions deemed inconclusive were due either to improper formulation or to the fact of requiring information not available to the responder, and their existence indicates that both questionnaires require improvements. It must be pointed out that the questionnaires analyzed herein were not created specifically for APL analysis, and yet our results show that APL analysis is an appropriate tool to assess the degree of consistency of the answers and the overall quality of the survey, and to unveil problems leading to the reformulation and improvement of such questionnaires. Of course, this application of the APL ought to yield even better results when applied to questionnaires devised specifically for APL analysis.

Table 8.
PAA results for Q2-S3

		Results				Conclusions
Group	Question	μ_1	μ_2	Hc	Gc	Verdict
S3	F1	0,8	0,0	0,8	-0,2	VIABLE
S3	F2	0,8	0,0	0,8	-0,2	VIABLE
S3	F3	0,8	0,0	0,8	-0,2	VIABLE
S3	F4	0,8	0,0	0,8	-0,2	VIABLE
S3	F5	0,8	0,0	0,8	-0,2	VIABLE
S3	F6	0,8	0,2	0,6	0,0	VIABLE
S3	F7	0,8	0,2	0,5	0,0	INCONCLUSIVE
S3	F8	0,8	0,0	0,8	-0,2	VIABLE
S3	F9	0,8	0,0	0,8	-0,2	VIABLE
S3	F10	0,8	0,0	0,8	-0,2	VIABLE
S3	F11	0,8	0,1	0,7	-0,2	VIABLE
S3	F12	0,8	0,1	0,7	-0,2	VIABLE
S3	F13	0,8	0,1	0,7	-0,1	VIABLE
S3	F14	0,8	0,8	0,0	0,6	INCONCLUSIVE
S3	F15	0,8	0,1	0,7	-0,1	VIABLE
S3	F16	0,8	0,1	0,7	-0,2	VIABLE
S3	F17	0,8	0,2	0,6	-0,1	VIABLE
S3	F18	0,8	0,1	0,7	-0,1	VIABLE
S3	F19	0,8	0,2	0,6	0,0	VIABLE
S3	F20	0,8	0,2	0,6	0,0	VIABLE
S3	F21	0,8	0,4	0,4	0,2	INCONCLUSIVE
S3	F22	0,8	0,4	0,4	0,2	INCONCLUSIVE
S3	F23	0,8	0,3	0,5	0,0	INCONCLUSIVE
S3	F24	0,8	0,1	0,7	-0,1	VIABLE
S3	F25	0,8	0,1	0,7	-0,1	VIABLE
S3	F26	0,8	0,1	0,7	-0,2	VIABLE
Average		0,8	0,1	0,7	-0,1	VIABLE

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