Consumer information on Broadband Speed and Net Neutrality Experiment

Final Report

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1 Introduction and Executive Summary

This study reports the results of a controlled laboratory experiment on consumer choice of broadband packages. Specifically, we examine four different treatments in a two-by-two design, in an experiment resembling actual broadband choices as currently employed in markets.

The experiment is designed to test the impact on choice of how information about packages is presented to consumers, and whether the presentation of superfluous information (which is not important for choice) impacts upon consumer choice. The objective is to inform Ofcom about the relative effect of different ways to present information on broadband features. We understand that currently broadband providers do not have a unique way to present such information – i.e. some provide more information than others often in different ways. This means that offers by different providers are often not easily comparable. The options considered in this experiment assume instead that broadband providers present information on their packages that is strictly comparable. In other words, we take the beneficial effects of some kind of standardization of information for granted[1] and then test whether different comparable ways to provide detailed service features perform differently.

There is another important feature of the way information for broadband packages is provided to consumers. Information is about technical features – i.e. speed, service prioritization and usage caps - which consumers have to interpret to understand what it means for the quality of the services they want to access – i.e. the quality of the videos they can watch. It is this need to translate information on technical inputs into the quality of the services consumers receive that makes this exercise not straightforward for consumers.

Participants in the experiment are given the user requirements of a hypothetical internet user and are offered two alternative broadband packages. Participants must choose the package that is more appropriate for them given their internet use. They must also choose whether to search for more information about the packages before making their package choice.

The two principle treatment variables are:

a. Coding: the way that the packages are presented, either in detailed numerical terms or through colour coding of key variables such as download speeds.

b. Information: the presence (or absence) of superfluous information in the package description, that is, information that should not affect the consumer's choice.

This controlled laboratory experiment implements each combination of coding and information. This type of design enables us to pin down the causes of differences in broadband package choice behaviour and potentially identify any interaction effects – the effect of the combination of coding and information changes. Each subject encountered one combination of coding and information and made 50 broadband package choices.

[1] For a recent large-scale experimental study that demonstrates the beneficial effects of standardization of information, see Chater, Huck, and Inderst's (2010) report on retail finance for DG SANCO.

For subjects that are able to process the information, we would expect that numerical coding would be superior as the information provided by colour coding is coarser. We would expect that superfluous information would not make the decision better and potentially may make it worse. However, if consumers suffer from cognitive limitations or information overload, colour coding of essential variables could help them to process available data more efficiently.

In broad terms we observe that subjects chose the incorrect package for their usage profile in a large proportion of cases, irrespective of the type of and how the information is provided to them. This is a useful premise to interpret the main results in the appropriate context.

We observe that the provision of information in numerical terms helps consumers to make, on average, better choices than under colour coding. The frequency of optimal choice increases by approximately 6 percentage points. One consequence of colour coding is that consumers tend to search too much.

There are however, also some consumers who do benefit from colour coding. We find that consumers who should make a decision based on freely available headline information but do continue to search are more likely to choose the best package when the key information is colour coded. This demonstrates the potentially beneficial effects of colour coding in environments where consumers are rather uncertain about which information they really need to make a good choice.

As would be expected, superfluous information tends to make things worse, specifically when the key variables are presented in numerical fashion.

Another important finding is that that subjects tend to gravitate towards the more expensive broadband package, when a cheaper package may be as good or better given their requirements. Such consumer behaviour can lead to excessive prices even in the presence of intense competition, simply because the incentive to offer lower prices is considerably reduced.[2]

Finally, we observe that the quality of choices improves significantly and substantially over time. From the first to the second half of the experiment the frequency of optimal choice increases by 8 percentage points. This is driven by feedback half way through the experiment on the number of incorrect choices made. When consumers realise they are not choosing the best package given their requirements they appear to try harder in the future.

[2] For a survey documenting the effects of consumer biases on competition between firms, see Duke, Huck, and Zhou' (2011) study for the OFT.

2 The experimental environment

The task is to implement an environment that allows Ofcom to compare directly the effects of information and its presentation on broadband choice. The experiment is designed to capture all the important real world details in a controlled setting: the main features of consumers' actual internet use, features of broadband packages and the presentation of information. It is, however, necessary to simplify some aspects of the real world in order to reduce noise in subjects' decision making. If we included all complexities of the field in the experiment then, for given sample size, the ability to isolate the drivers of consumer choice is reduced. This is, for example, the reason we focus on choices between just two alternatives.

When choosing parameters for an experiment like this (where there is no theoretical model that offers guidance on how different parameters should be related to each other) one has to rely on some degree of judgement. In each case we have carefully considered how the choice of one parameter impacts on the overall environment and the choice problems the consumer subjects face. As such, we always tried to capture key aspects of real markets while maintaining simplicity and coherency of the environment.

The environment is directly informed by existing practices in communications environments. As mentioned above, when we use a simple environment we are able to better identify which features of the broadband choice processes are influencing behaviour and why.

In the experiment, consumers select broadband packages. They are given the user requirements of a hypothetical internet user. This user needs to purchase a broadband package. They are offered two packages. Initially, they only see a limited amount of (headline) information about each package (this initial information always includes a maximum download speed and a price). However, they are also given the opportunity to search for more information about the available packages before making their selection. In some problems, additional search would be a waste of time as the information provided initially is sufficient to make the correct package choice. The subject's task is to correctly choose whether to search for more information and then to correctly identify the appropriate package.

The instructions given and read to subjects in the experiment are reproduced in Annex 1.

In the following sections, we describe how the user requirements and packages are generated and how the treatments are implemented.

2.1 User requirements

There are 10 **internet activities** (email, web browsing, YouTube, iPlayer HD, file downloads, Skype calling, home working, online radio, online gaming and P2P file sharing) that a user could potentially engage in. Specifically, a user can either "not use", "use a low quantity", "use a medium quantity" or "use a high quantity" of each activity.

For each quantity of each activity, a certain amount of data is required, certain download and upload speeds are needed, and certain traffic management policies may be beneficial.

For example, for the "Youtube" activity, a "low quantity" user would use 0 to 2 hours per month, a "medium quantity" user would use 2 to 10 hours per month and a "high quantity" user would use 10 to 40 hours per month.

There are 10 **user type profiles** corresponding to hypothetical types of user of the internet. Each user type profile specifies how much of each activity a user engages in. For example, the "homeworker" profile uses a “high quantity” of email, “high quantity” of web browsing, a “high quantity” of home working, “low quantity” of Youtube, and does “not use” iPlayer HD, online radio, gaming or P2P. This combination of internet activities will determine their overall usage requirements in terms of download speed, upload speed, data usage and traffic prioritization.

For each problem in the experiment, one **user type** is selected at random from the 10 user type profiles. The actual usage requirements are generated using the ranges for the amount of time spent on each individual service per month (there is an element of randomness about this).

We noted that some households consisted of more than one user sharing an internet connection. So, we are also able to generate multi user households by specifying between 2 and 4 users (where each user is generated in the manner specified above). This is to represent the case where there is one purchaser of broadband buying for their household.

2.2 Packages

For each problem, the subject is offered two packages, from which they have to choose the most appropriate for the user profile.

We generate the two packages for each problem as follows. There are three levels of packages (this broadly corresponds to what is on offer in the field at the moment), level 10, level 20 or level 50 which are the advertised "up to" download speeds (e.g. “Up to 10Mbps”, “Up to 20Mbps”, or “Up to 50Mbps”).

For each level of package, there is a distribution on the "average download speed", "upload speed", "monthly usage allowance", "price" and "traffic management". Generally, a package at level 10 will usually be worse than one at the level 20 on most attributes, but not always and not for all users (price will usually be lower too).

In terms of the traffic management, there are two types of policies that consumers may face, and these broadly correspond to existing ISP policies.

a. Some ISPs restrict download speeds at peak time for all or for P2P traffic. As such, each package has an attribute called "Download data consistency during peak time". This may take the values “None”, "download slowdown at peak times", "download slowdown of P2P at peak times".

b. Some ISPs prioritise traffic that relies on low latency. For example, video calling or remote desktop home working software require more responsiveness than web browsing or email. We implement these through a package attribute called "prioritisation of real time services". This may contain any of the following: "prioritisation of gaming", "prioritisation of VOIP", "prioritisation of streamed video", "prioritisation of P2P".

For each level of package, there is a distribution on the likelihood of these. So for a package on "level 20" (a mid range package), there is 40% chance of "download slowdown at peak times" and a 30% chance of "prioritisation of VOIP".

2.3 The implementation of the treatments

The main purpose of the experiment is to compare colour and numerical coding of the packages and to compare treatments with and without superfluous information.

In terms of presentation of the packages: consumers see some "headline" information about a package and can search for extra information.

The headline information provided always includes "maximum download speed" and "price". The other information provided in the headline is randomised. So, whilst the "monthly usage allowance" is shown in the headline information 90% of the time, the "average download speed" is only shown 20% of the time.

Example screens from the experiment are shown in Annex 2.

In terms of traffic management, if there is a lot of prioritisation (which is deemed here good for the consumer)[3] or an absence of slowdowns, it is more likely to be shown in the headline information.

In terms of numerical and colour coding, we decided to use a simple "gold", "silver", "bronze" colour coding. Transforming numerical details into colour coding essentially requires a mapping from numerical ranges into the set gold, silver, and bronze for each attribute. This would require agreement in the industry or regulation. The key point is that necessarily the information provided in the colour-coded treatment is coarser, that is, it contains strictly less information.

The other treatment variation is the presence or absence of superfluous information. These are services that might look, to an uniformed consumer, like they may be of great benefit, but in reality are either not of benefit or are available for little cost elsewhere. As such, they should not enter the subject's consideration when choosing the better package. The superfluous information may be any of the following: "Adult content filtering", "free modem", "free anti-virus", "free technical support", "free on-line webspace", "free wifi hotspots", "10 free email addresses".

2.4 Experimental procedures

156 subjects from the University College London student subject pool participated in this experiment. Each subject encountered the same 50 problems involving broadband choice (but not in the same order). Amongst the 50 problems, 40 were single user problems and 10 were multi user households.

In each problem, the consumer sees the user requirements; that is, a listing of the activities that the user engages in and the amount of time spent on each activity. They also see the headline information for two broadband packages. There is also a "search" button, which, if pressed, reveals more information about both packages. Subjects select which package they think is appropriate. They then move onto the next problem. Example screens are shown in Annex 2.

[3] One concern which is currently discussed is whether prioritisation could lead to a decline in the quality of the services that are not prioritised ("best effort"). While this is an important policy consideration, for the purpose of this experiment we assume that offering priority access to some services would not affect in any way the quality of other content or services accessed via an Internet connection.

After 25 problems, subjects receive feedback about how many optimal choices they have made so far. Such limited feedback is in line with real life experiences where a user seldom learns whether they have chosen the best package.

An optimal choice is one where the subject chooses correctly whether to search for more information *and* then correctly chooses the best package for them. Subjects were paid £0.25 for each optimal choice they made in the experiment. Of course, in real life one might argue that it is much more important to choose the correct package and that it does not matter so much whether one found that package with little search and luck, or after exerting slightly exaggerated effort on the choice problem and we will consider this in our data analysis. However, for the incentivization of subjects in the experiment paying them only for perfectly optimal behaviour was an important "trick". If we had not done this, then otherwise uncontrolled expectations and risk attitudes would have affected behaviour. For example, if a subject believed there was some correlation between price (which she has observed in the headline information) and some important characteristic of a package for which she would have to search more, she could take the gamble and not search further even without perfectly knowing if the package was right for her. It is exactly this pattern of behaviour that we wanted to avoid. With our incentive scheme such beliefs about correlation are not important for optimal choice in the experiment.[4] If the subject cannot be perfectly sure that the package will satisfy her needs after having studied the headline information, she must continue her search under our incentives. This makes it far easier to decide whether observed behaviour was indeed optimal or not. Of the four possible combinations (don't search, choose package A; don't search, choose package B; search, choose package A; search, choose package B) there is always just one that is optimal in the experiment.

For deciding which package is optimal we have a very simple two-stage rule. A package must be able to satisfy the consumer's needs. If it does not, it can never be optimal regardless of its price. If both packages satisfy the consumer's needs, the cheaper is optimal.

Choosing to do a between-subjects design, where each subject encounters only one type of coding and one type of information presentation, rather than a within-subjects design, where an individual subject may encounter both, was a key design decision. It enables us to get (within the constraints of sample size and time frame of the study) the cleanest data set possible, where we observe subjects as they learn about the experimental design and parameters they experience, free of the potentially confounding effects.

In addition to the 50 broadband choice problems of the experiment, each subject undertook an incentivised 12-question IQ test, an incentivised 4-question broadband general knowledge test and a feedback questionnaire about the experiment.

Annex 2 reproduces a selection of the screen shots from the experiment. We can see the screenshots for a single problem (the same problem) in each of the four treatments (colour coding and numerical coding, with and without superfluous information) and before and after clicking the "search button".

The broadband general knowledge test and feedback questionnaire are reproduced in Annex 3.

Experimental sessions lasted on average 90 minutes and subjects' earnings were approximately £13.50 including a £5 show up fee. The maximum possible earnings subjects could make in the

[4] This ensures we have control over incentives in the experiment. Only information within the experiment is important for choice not external preferences or beliefs.

experiment was £21.50 including the £5 show up fee which is standard in these types of experiments.

3 Data analysis

Our data analysis will proceed in two steps. First, we will provide and discuss some measures of performance, indicating the main differences between treatments and highlighting other interesting findings and illustrating these through some summary tables and figures. We also discuss the two elements of the decision problem (search and package choice) separately and investigate learning.

Secondly, we will conduct a rigorous econometric analysis to identify size and significance of elements of the decision problem and treatment variables on the outcomes.

3.1 Aggregate performance & decision making

Each subject faced the same 50 problems, although the way they were presented to the subject varied according to whether the subject experienced numerical or colour coding and also whether there was superfluous information of not. A subject should search for further information in 24% of the problems and should choose the cheaper package in 66% of the problems.

Table 1 summarises the outcome of the experiment for each of our four treatments. The outcome measured is the proportion of "optimal choices"; an optimal choice is one where the subject makes both the correct decision on whether to search or not and the correct decision on which package to choose in a given problem.

Overall, we can see that the treatments with numerical coding seem to be associated with better performance and similarly those with only relevant information seem to do better than those with superfluous information.

There does not seem to be any "interaction effect" of superfluous information and colour coding. While we might have hypothesized that in the presence of superfluous information, colour coding may have a more positive effect of helping subjects to focus on the relevant information, but from an aggregate perspective this does not seem to be the case here.

Table 1: Performance Summary

Treatment	Subjects	% of optimal choices
1) Colour coding with only relevant information	40	45.5 (11.5)
2) Colour coding with superfluous information	42	42.4 (13.5)
3) Numerical coding with only relevant information	38	50.7 (10.1)
4) Numerical coding with superfluous information	36	49.4 (11.2)
Total	**156**	**46.8 (12.1)**

A Mann-Whitney test, where we take the percentage of optimal choices for each subject and compare the distribution of percentages across treatments, indicates that numerical coding is significantly better ($p<.01$), but there are no significant differences arising from superfluous information ($p=.30$).

One clear observation from Table 1 is that, regardless of treatment, subjects find it hard to make good choices. This appears to be particularly important if we take into account that our subjects might be more internet literate than the general population.

MAIN FINDING 1: (a) *Regardless of the information that is available and the way in which the information is presented, consumers find it hard to make optimal choices. (b) On average, consumers do better when they have access to numerical information rather than information that is colour coded.*

3.2 Search and Package Choice decisions

With relatively low rates of optimal decision-making, subjects are clearly making a substantial numbers of errors. In order to see where the errors in subjects' decisions arise, Table 2 breaks down the analysis into the two decisions and provides the percentage of correct decisions for the search problem (whether to choose to search for extra information) and for the package choice problem (which package to choose).

We can see that the package choice decision is somewhat easier for the subjects than the search decision, with 70.9% of correct choices in the former but only 61.6% in the latter. Further, we can see that the standard deviation for the latter measure is much higher. We can see the effect of this more clearly below when we look at a histogram of the distributions of proportion of correct search and package choices per subject (Figures 1 and 2).

In order to understand how search and package choice relate to each other, we show the data from Table 2 again in Figure 3, this time in a "tree structure" that shows first the share of those who did or did not choose the best package, and then for each of these groups, the share of those who did or did not search optimally. This is very revealing as it essentially shows that subjects who are unable to find the best package appear to search completely randomly. In other words, those unable to identify the best package are behaving, when it comes to search, as if they simply flipped a coin.

The histograms in Figures 1 and 2 show that, especially in the colour coding, there is a significant fraction of subjects that do very poorly in the search decision part of the problem. This is perhaps unsurprising, especially given that search is optimal only in 24% of cases – a subject who is uninformed about broadband generally may not realise that he has all the important information required and choose to search.

Table 2: Correct search and package choice		
Treatment	**% of correct search decisions (standard deviation)**	**% of correct package choices (standard deviation)**
1) Colour coding with only relevant information	60.4 (12.8)	70.8 (6.4)
2) Colour coding with superfluous information	58.2 (15.0)	69.3 (7.1)
3) Numerical coding with only relevant information	63.7 (10.1)	73.1 (8.1)
4) Numerical coding with superfluous information	64.6 (10.2)	70.5 (8.4)
Total	61.6 (12.5)	70.9 (7.6)

Figure 1: Proportion of correct package choice

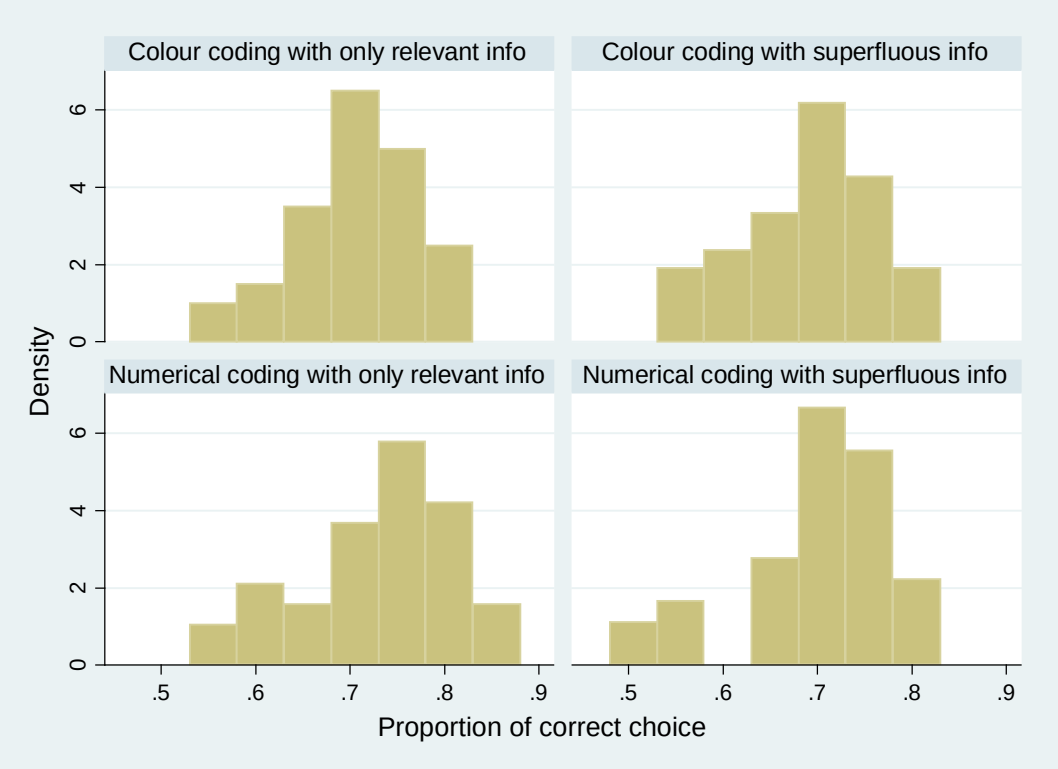


Figure 2: Proportion of correct search choice

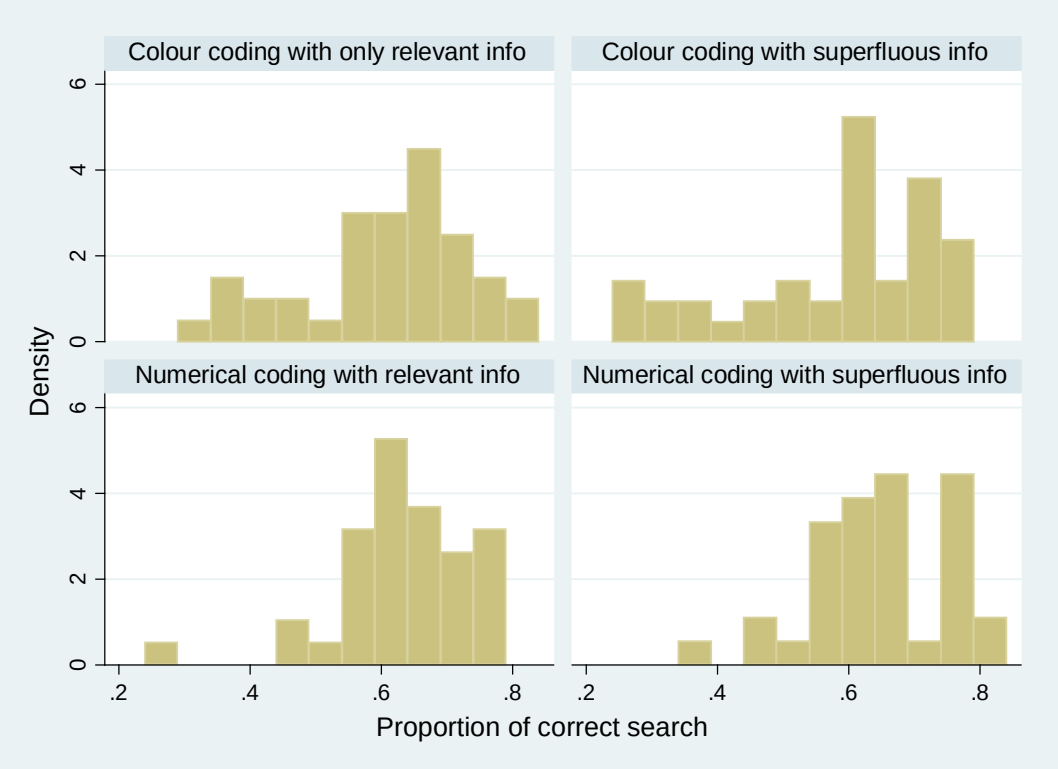


Figure 3: Tree diagrams for search and package choice

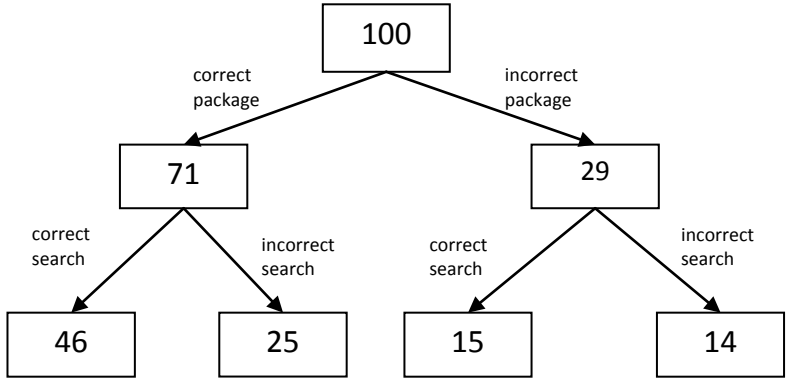


Figure 3a: Colour coding, no superfluous info

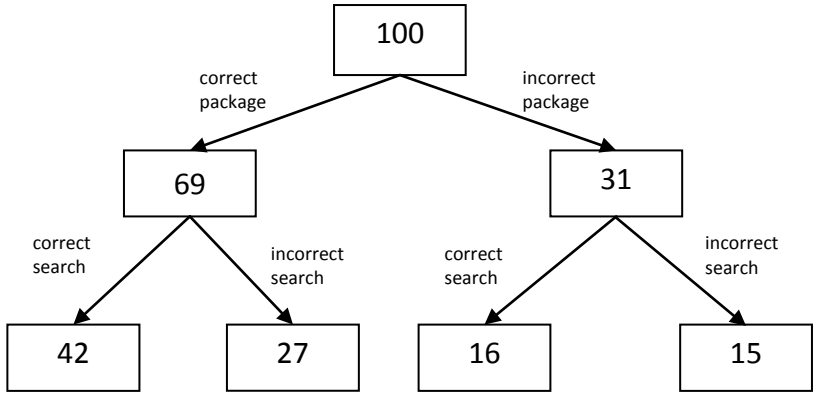


Figure 3b: Colour coding, with superfluous info

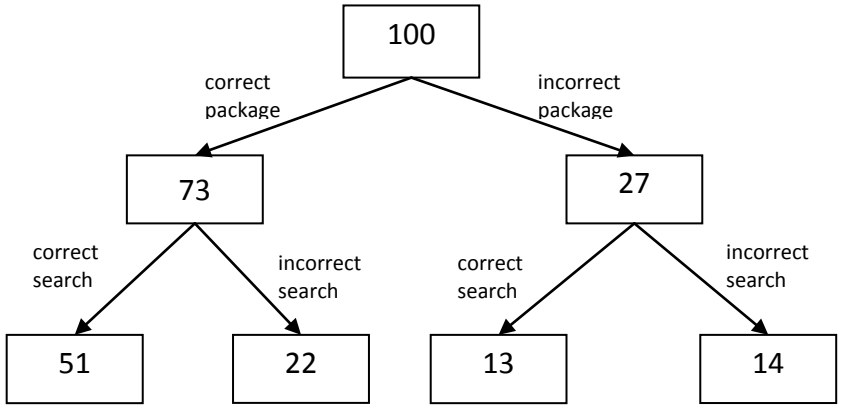


Figure 3c: Numerical coding, no superfluous info

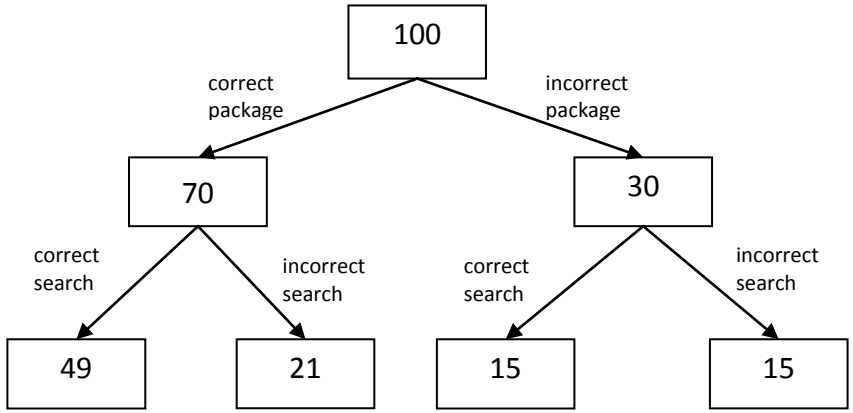


Figure 3d: Numerical coding, with superfluous info

We look in more detail at the distribution of search behaviour for the four treatments in Table 3, where we show the proportion of problems where subjects undersearch and oversearch for each treatment (the numbers in parentheses are the proportions for the second half of the experiment).

Recall that it is correct to search in only 24% of problems. It is only possible to have "undersearch errors" in these problems. Similarly it is only possible to have "oversearch errors" in the remaining 76% of problems. Hence, the disparity between oversearch and undersearch shown in Table 3 is not as dramatic as it first appears.

However, there is still a tendency for oversearch rather than undersearch. As explained earlier, we might expect some amount of oversearch initially anyway as subjects familiarise themselves with the experiment and try to learn more about the possible characteristics for packages.

When we look at the effects of the various treatments on over- and under-searching, we see that colour coding seems to generate more oversearch errors. This is unsurprising: with no "key" to tell them precisely what level of performance each colour provides, subjects are cautious and search more.

The figures for the second half of the experiment (in parentheses) indicate that the ratio of oversearch errors to undersearch errors (25.4:9.1) approaches the ratio of problems where these types of errors may occur (76:24). In other words, both types of errors become equally common over time. Indeed, the proportion of undersearch errors is significantly higher in the second half than the first. This indicates that, whereas subjects are cautious in the first half of the experiment and try too much to find out information, they are more confident (indeed, overconfident) in the second half, which leads to some mistakes.

Table 3: Oversearch & undersearch

Treatment	% of problems with oversearch	% of problems with undersearch
1) Colour coding with only relevant information	33.7 (25.9)	6.0 (8.3)
2) Colour coding with superfluous information	34.0 (28.6)	7.8 (10.0)
3) Numerical coding with only relevant information	29.5 (23.3)	6.8 (9.5)
4) Numerical coding with superfluous information	28.6 (23.3)	6.8 (8.6)
Total	31.6 (25.4)	6.8 (9.1)

Therefore, in summary:

MAIN FINDING 2: (a) *Consumers perform better in identifying the optimal package than they are in optimal search. (b) There is a tendency to search too much. (c) Consumers who are unable to identify the optimal package appear to search at random.*

Now, let us focus on the errors in the choice of package, arguably the most important outcome variable for real-life consumers. Recall that the cheaper package is the correct package in 66% of the problems. In Table 4, we tabulate, for each treatment, the proportion of correct choices when the cheaper package is the correct choice and when the more expensive package is the correct choice (we consider the effect of the actual price difference on the choice in the regressions). Table 4 shows that subjects make many more errors when the cheaper package is the correct package, but this does not seem to be related to the choice of treatment.

This is in line with the idea that subjects might take price as an indicator of quality, regardless of whether this is true. In any case, we clearly observe that subjects are drawn towards more expensive packages – an inefficient behaviour that can induce disincentives for providers to offer cheap packages.

We summarise this in:

MAIN FINDING 3: *Consumers display a tendency to buy the more expensive package regardless of whether they actually need it or not. Consequently, they make more mistakes when the cheaper package would be optimal for them. This type of consumer choice bias may significantly reduce providers' incentives to compete vigorously.*

Table 4: Package choice errors		
Treatment	**% of correct choices when cheaper package is correct**	**% of correct choices when more expensive package is correct**
1) Colour coding with only relevant information	68.0	79.2
2) Colour coding with superfluous information	68.6	73.7
3) Numerical coding with only relevant information	70.5	78.9
4) Numerical coding with superfluous information	65.8	79.8
Total	68.3	77.8

3.3 Learning

In the experiment, there is very little feedback to subjects from the experimenter. Only after 25 problems is there any feedback and even this contains little information: subjects only learn for how many problems they chose optimally. They are not told whether they have made package choice errors or search errors (or of the nature of the search errors – i.e. over or under search). So, we might assume that it is very difficult for subjects to learn in such an environment.

However, each problem itself provides information: there is a new user, whose usage requirements can be compared to the usage requirements of previous users, so that a subject might form some idea about the relative ranking of a user's requirements.

Similarly, for each new problem a subject sees two new packages (or at least part of the package, if they don't choose to search). From this they can have an idea of which types of packages offer which levels of services and what sort of information can (and cannot) be obtained by searching further. So, the opportunity for learning is somewhat greater than it may first seem.

In order to study learning, we tabulate the proportion of optimal decisions, correct search and correct package choice by half of the experiment in Table 5. Table 5 shows that there is a large learning effect. In terms of optimal choices, the increase is about 24% (from 41.9% to 51.8%). The cause of this effect seems to be evenly distributed between improvements in search behaviour and improvements in package choice. Again, there is no evidence of treatment effects; that is, the improvement seems broadly similar in the four different treatments.

In order to see the effect of learning over time, we plot the proportion of optimal choices in each period for each treatment in Figure 4. This shows us that there is a large amount of noise in the data,

but there is a significant learning effect in each treatment (the slope of the line is positive at a statistically significant level).

We summarise this in:

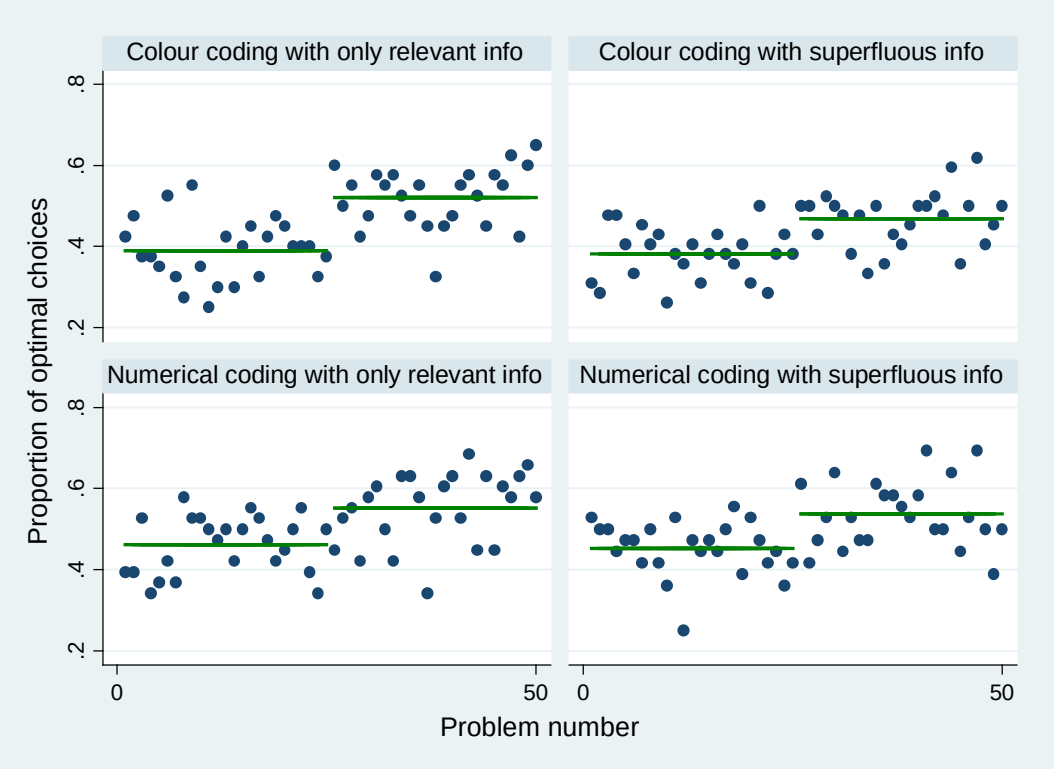
MAIN FINDING 4: *There is substantial learning in all treatments. However, even in the second half of the experiment consumers are still far away from optimal behaviour with roughly 25% of suboptimal packages chosen and over a third of search decisions being misguided.*

Remember our finding 1 above, we observed that regardless of how the information is presented, consumers overall find it difficult to make optimal choices.

Table 5: Learning

Treatment	% of optimal decisions (first half, second half)	% of correct search decisions (first half, second half)	% of correct package choices (first half, second half)
1) Colour coding with only relevant information	38.9, 52.1	55.0, 65.8	67.4, 74.1
2) Colour coding with superfluous information	38.1, 46.8	55.1, 61.2	66.8, 71.8
3) Numerical coding with only relevant information	46.2, 55.2	60.1, 67.3	69.0, 77.2
4) Numerical coding with superfluous information	45.2, 53.7	61.1, 68.1	67.1, 73.9
Total	41.9, 51.8	57.7, 65.5	67.6, 74.2

Figure 4: Learning: Optimal choice overtime



4 Regression Analysis

In the previous section, we have summarised the data. In order to analyse it in a more comprehensive and rigorous way and find the marginal effects of the various components, we perform a regression analysis.

We will again add some "main findings" items but only insofar as the regressions uncover qualitatively new results. Wherever they just pin point the size of quantitative effects and essentially confirm what we have seen in the above descriptive analysis we shall refrain from such short summaries.

The regression analysis follows the same path as the analysis in the previous section: we first focus on optimality, then on correct search and finally on correct choice as dependent variables to be explained. Each regression is a "probit" regression, as the dependent variable is the likelihood of making a correct choice.

We have a sample of 7800 observations (156 subjects each making 50 decisions). In each regression, to account for the fact that there are 50 observations from the same subject, we cluster our standard errors by subject.

The explanatory variables we use are given in Table 6. The variables included are the main treatment variables (numerical / colour coding and superfluous / relevant information), a variable to control differences in performance between the first and second half of the experiment and variables specific to the individual problems (to control for the effects of the problems).[5]

For the initial regression specifications, there are two sets of the results. The second column shows how the results change when personal characteristics are added to the regression specification. Personal characteristics include age, gender, mathematical knowledge, IQ and prior knowledge about broadband. We discuss the personal characteristics and their effect in a later section.

The significance level of a coefficient is indicated by stars, with significance levels 10% (*), 5% (**) and 1% (***).

Table 6: Explanatory variables

Variable name	Description
numerical	Takes value 1 for numerical coded treatments and 0 for colour coded treatments.
superfluous	Takes value 1 for treatments with superfluous information and 0 for treatments with only relevant information.
half	Takes a value 1 for first half and 2 for second half to account for differences in performance between the 1st and 2nd half of the experiment

[5] We also ran the regressions including a time trend variable which took a value between 1 and 50 to capture learning across rounds. In the presence of the dummy for first and second half, the coefficient for the trend variable is not significantly different from zero, suggesting that all learning stems from the feedback information, not from the practice of making choices as such.

cheaper	Takes the value 1 if the cheaper package is the correct package.
pd	The difference in price between the two packages
pd_cheaper	pd * cheaper. The interaction of pd and cheaper.
Personal characteristics	Age, gender, mathematical skill, IQ and knowledge about broadband

4.1 Overall Optimality

Table 7 reports the regression analysis for overall optimal choice, that is, correct package choice and optimal search.

Table 7: Effects of variables on optimal decision making

	Without personal characteristics	With personal characteristics
	Coefficient (standard error)	Coefficient (standard error)
numerical	0.062*** (0.019)	0.061** (0.019)
superfluous	-0.022 (0.019)	-0.020 (0.019)
half	0.103*** (0.011)	0.103*** (0.011)
cheaper	-0.049*** (0.018)	-0.049*** (0.018)
pd	0.000 (0.001)	0.000 (0.001)
pd_cheaper	-0.002* (0.001)	-0.002* (0.001)
	Note: N = 7800	

Table 7 confirms the result in the previous section: that numerical coding has a significant and positive effect on the probability of a correct choice (correct package and correct search). Going from colour coding to numerical coding, keeping all else constant, results in a 6.2 percentage point increase in the likelihood of making an optimal choice. This is seen in the positive estimated coefficient for 'numerical' which shows that as compared to colour coding there is an improvement in both search and package choice. The co-efficient is statistically significant at the 1% level. This means that we can be 99% sure that this positive relationship between numerical information and optimal choice is not simply due to chance.

Further, we find that while superfluous information does have a negative effect, this effect is not statistically significant. We also find that if the cheaper package is the correct one, subjects perform significantly worse. This is seen in the negative estimated coefficients for 'superfluous' and 'cheaper' in Table 7. Furthermore, we find that if the cheaper package is the correct one, then an increasing price difference between the two packages decreases the likelihood of making an optimal choice; that is, subjects have more difficulty when packages are not closely priced if the more expensive one is correct.

As before, we now decompose the choice for a given problem into two parts: firstly, we investigate search behaviour and then we look at the package choice behaviour.

4.2 Search

Table 8 shows results from an estimation where we regress a binary variable that indicates whether or not a subject searched correctly on the same regressors as before. The results are similar to those above on overall optimality. Numerical coding significantly enhances the quality of search and superfluous information again has no significant effect.

A striking finding is the coefficient on cheaper, which indicates that if the cheaper package is correct, the likelihood of a correct search decision is 18 percentage points lower. Subjects seem to focus too much on price.

Table 8: Effects of variables on correct search choice

	Without personal characteristics	With personal characteristics
	Coefficient (standard error)	Coefficient (standard error)
numerical	0.049** (0.019)	0.050** (0.020)
superfluous	-0.007 (0.020)	-0.009 (0.020)
half	0.099*** (0.012)	0.099*** (0.012)
cheaper	-0.188*** (0.017)	-0.188*** (0.017)
pd	-0.005*** (0.001)	-0.005*** (0.001)
pd_cheaper	0.010*** (0.001)	0.010*** (0.001)
	Note: N = 7800	

4.3 Correct choice of package

Table 9 shows results from an estimation where we regress a binary variable that indicates whether or not a subject chose the correct package (regardless of correct search) on the same regressors as before. Arguably, this is the most important decision for real-life consumers outside the laboratory.

Table 9: Effects of variables on correct package choice		
	Without personal characteristics	With personal characteristics
	Coefficient (standard error)	Coefficient (standard error)
numerical	0.018 (0.012)	0.018 (0.012)
superfluous	-0.021* (0.012)	-0.019* (0.012)
half	0.051*** (0.010)	0.051*** (0.010)
cheaper	0.101*** (0.017)	0.101*** (0.019)
pd	0.005*** (0.001)	0.005*** (0.001)
pd_cheaper	-0.015*** (0.001)	-0.015*** (0.001)
	Note: N = 7800	

This time, we see a slightly different picture. Interestingly, numerical coding does not significantly improve decision making, but superfluous information does make it significantly worse.

MAIN FINDING 5: *The presence of superfluous information can reduce the quality of broadband choice.*

On the face of it, if the cheaper package is the correct one, this appears to improve decision making. However, the effect of the interaction term and the price difference (pd) term mean that this interpretation is misleading. For a price difference of about 10, the combined effect of the three variables is roughly zero, with the overall slope on the price difference being negative. In other words, if the cheaper package is optimal consumers are less likely to choose it when the alternative is substantially more expensive. The more expensive the (suboptimal) alternative, the more likely is the consumers to choose it.

This warrants a summary in form of:

MAIN FINDING 6: *The more expensive an alternative suboptimal package is the more consumers are attracted to it.*

It appears that especially large price differences trigger a "must-have" temptation. This implies that incentives for vigorous price competition among providers may be much diminished.

So far, we have examined the package choice decision without considering the search decision already taken. However, the two are related – subjects that have a good understanding of broadband or that are more able at the task and get the search decision correct are more likely to get the package decision correct. Similarly, those that do not search correctly may have specific biases that also affect their package choice. This suggests that we examine the correct package decision for the following three groups separately: those that searched correctly, those that over searched and those that under searched.

Table 10 shows results from an estimation where we regress a binary variable that indicates whether or not subjects chose the correct package on the same regressors as before for the three different sub groups.[6]

Table 10: Effects of variables on correct package choice			
	Searched correctly	Under searched	Over searched
	Coefficient (standard error)	Coefficient (standard error)	Coefficient (standard error)
numerical	0.036*** (0.014)	0.032 (0.042)	-0.044** (0.021)
superfluous	-0.028** (0.014)	-0.032 (0.042)	-0.010 (0.021)
half	0.039*** (0.011)	0.277*** (0.050)	0.043** (0.021)
cheaper	0.156*** (0.022)	-0.044 (0.069)	-0.115** (0.045)
pd	0.006*** (0.001)	-0.003 (0.003)	-0.003 (0.002)
pd_cheaper	-0.015*** (0.002)	0.012** (0.006)	-0.014*** (0.002)
	N = 4803	N = 534	N = 2463

- For those that have already searched correctly, we see a similar picture as before – numerical coding is significantly better. This is perhaps not surprising. The subjects that have already searched correctly are likely to be the more sophisticated ones that understand the package and usage requirements and can make use of the finer information provided by numerical coding to make better choices.

- For those that under search, that is, those who take a decision on the basis of the headline information even though this information is not sufficient for picking the right package, both treatment variables are insignificant.

- For those that over search, we see a completely different result: colour coding makes decisions significantly better and there is much less learning. Further, when the cheaper package is the correct one, they are less likely to make the correct choice – and this problem gets worse as the package price difference increases. Possibly, the types of consumers in this subgroup (32% of all observations) are those who are more cautious, wanting to find out as much information as possible, because their understanding of broadband and the requirements of a given user is lower.

We believe the last finding is one of the most striking and perhaps most important of this study as it demonstrates the potentially beneficial effect of colour coding. Remember, colour coding is strictly less informative than numerical presentation and any standard economic approach would predict that colour coding can *never* have a positive effect on consumers' performance. However, here we see very clearly that consumers who lack the confidence of making decisions based on just headline information are aided by colour coding. As they accumulated too much information and thus,

[6] This regression does not include personal characteristics. When we run the same regression including personal characteristics we observe that they make no difference in observed choice.

perhaps, are prone to information overload, colour coding appears to help them to focus on the most relevant variables.

This observation suggests that colour coding and numerical information may well serve two different types of consumers best. Consumers who have lower confidence in internet markets and in their choice of package may benefit from the coarser colour coded information. While consumers who have more confidence and perhaps more interest in package information, can use this information to aide their choice. This is worthy of a summary in:

MAIN FINDING 7: *In contrast to what standard economic models would predict, colour coding can improve the quality of broadband choice in some circumstances. In particular, when consumers lack confidence in choosing among packages that are clearly ranked on the basis of little information, colour coding helps them to pick the better package.*

4.4 IQ, Broadband knowledge Personal characteristics

In addition to the 50 problems, the subjects also faced a 12 question IQ test, a four question broadband knowledge test and completed a survey giving some personal characteristics: age, gender, and whether they had passed Maths A Level.

In an experiment where cognitive ability played a large part, we would expect that IQ would be significantly positively correlated with performance in an experiment. However, this experiment is not really in that field. The experiment is more about judgment (about whether a certain package meets the user requirements), general knowledge about broadband and specific knowledge about the requirements of certain internet services. As such, it is not altogether surprising that none of the personal characteristics that we observed significantly affected the results.

We can see this clearly in Tables 7, 8, 9. In these tables, the second column contains the results of the regressions that include these personal characteristics (we omit the coefficients of these personal characteristics – none was significant). The second column coefficients and significance values are almost all identical to the first column, which indicates that the personal characteristics had no effect on the results.

However, one should perhaps be cautious in inferring that, in real life, there would be no effect of IQ. It may be the case that there is some “hurdle” level of IQ, above which IQ doesn’t make any further difference – and that all of the participants in the experiment are over that hurdle.

Certainly, one might think that those that are less able or confident with numbers in real life are more likely to fall into the category of subjects that are underconfident and over search and for whom colour coding may, thus, be beneficial.

The broadband knowledge multi choice quiz consisted of 4 questions. More than 60% of subjects got precisely two correct answers and no subject got zero or four correct answers. Given these results (the lack of variation between subjects), it is unsurprising that the results don’t provide any significant explanatory power.

5 Concluding remarks

We implemented a controlled laboratory experiment to test consumer broadband package choice across two main treatments that varied the way that the packages were presented:

- whether information about main package features were presented in numerical or colour coded terms; and,
- whether superfluous information was included in the package choice which was not important for package choice.

We observe that subjects find it difficult to make optimal choices irrespective of how the information is presented. This appears to be strong result as our subjects were university students used to computational tasks, and can be expected to be more technologically savvy as compared to the general population. Further, our experimental environment is simplified as compared to the field (with only two packages to choose from) and we assume more consistency in how information is provided as compared to current broadband providers.

Very broadly, our findings are suggestive of two types of consumers, those with some justified confidence in the ability to make broadband choices and those who are rather more uncertain. The latter group finds it extremely difficult to decide whether headline information is sufficient or not and, consequently, they basically search at random. When it comes to choosing a package they benefit from colour coding, presumably because it helps them to identify the important variables. On the other hand, more confident consumers who make fewer search errors benefit from the presence of precise numerical information.

When we breakdown optimal choice into choosing the best package and choosing whether to search for more information about packages or not, we observe that on average, consumers are better and choosing the package, and there is a tendency for consumers in the experiment to search too much for additional information which would not help their choice.

Consumers in the experiment tend to choose the more expensive package whether it is the better package given their own requirements or not. Mistakes are greater when the cheaper package is the better package for their needs. Indeed, the more expensive a package which is not the best for their requirements the more likely they are to select it.

The tendency to select the more expensive package could reduce the incentive for providers to compete, as some consumers hover towards the more expensive end irrespective of need.

Consumers do improve in their choice overtime. Choice is better in the second half of the experiment as compared to the first, although choice and search is still far from optimal. This seems to be mainly driven by the feedback provided halfway through the experiment on the number of correct choices made, which in turn may make subjects try harder.

Overall numerical information helps consumers make better choices than colour coding. This can be expected as numerical is more precise while the coarser colour coding provides much less information. However, we do observe that colour coding can improve the quality of broadband choice in some circumstances. In particular, when consumers lack confidence in choosing among packages that are clearly ranked on the basis of little information, colour coding helps them to

pick the better package. On the other hand, the presence of superfluous information makes it harder for consumers to choose the correct package.

Overall, this suggests that an environment where all key information is colour coded but where at the same time the precise numerical information can be easily accessed and where superfluous information is suppressed, would maximize the quality of consumer choice in broadband markets.

Annex 1 Experiment instructions

Welcome to this experiment. We kindly ask you to read these instructions carefully. Please remain silent throughout the entire experiment. Do not talk to your neighbour and do not try to look at other participants' screens. If you have a question, raise your hand and we will answer it privately. In addition to your show-up fee you can earn a significant amount of money in this experiment depending on the choices that you make. However, if you do not comply with the rules, we will have to exclude you from payment.

The experiment is about choosing broadband (internet) packages. You will face 50 tasks. Each task is structured in the same way: you will be given a "consumer profile" - a description of the internet usage of a person or household - and you will see two broadband packages, A and B, from which you can choose.

For each of these packages, you will see the package price and some other headline information upfront: for example, the total data allowance or the maximum download speed. In addition, there is a search button that you can click on which reveals more detailed information about both packages; for example, about upload speed or certain extras.

For each of the tasks, we have asked an expert from the broadband regulator, OFCOM, to decide which package is best suited for the consumer profile. In determining what is best, the expert has applied the following the rules:

- If both packages are capable of satisfying the consumer's need fully, one should choose the cheaper one.
- If one package can satisfy the consumer's needs fully and the other does not, one should choose the one that does (regardless of price).
- If neither package can satisfy the consumer's needs fully, the one that comes closest to doing so should be selected.

For each task, one of the packages is better than the other. However, choosing which package is better is not the only thing you have to do. There is one further complication.

In some cases, the upfront information that you see (i.e. the information you see without clicking on the search button) is sufficient to determine which of the two packages is better; for example, when it is clear that one package can fully satisfy the consumer's needs and also that the other cannot. In these cases, searching out further information would be a waste of time. Thus, the best thing a consumer could do in these cases is to make the decision about the better package straight away without engaging in further search.

In other cases, it will be impossible to decide for sure which of the two packages is better suited for the consumer profile. Maybe one looks better than the other does, but it's not entirely clear whether it really is. In these cases, the best thing the consumer can do is to search to find out more and make a decision only when having a complete picture.

So, there are always four things you can do - (i) choose package A straightaway, (ii) choose package B straightaway, (iii) choose package A after further search, or (iv) choose package B after further

search - and only one of these four is the optimal choice. Only if you make this optimal choice will you earn an amount of money in the task. For each optimal choice, you will earn £0.25.

You will first be confronted with a cycle of 25 tasks. After you have made the 25 choices, you will be informed how often you chose optimally. Then you will see a second cycle of 25 tasks at the end of which you will again be informed about your performance. If you choose correctly in all tasks, you will be paid an extra £12.50 on top of your show-up fee of £5.

After the two cycles of tasks, we will also ask you to do the following:

- 1. Answer a short multiple-choice quiz of 12 questions, where you get an extra £2 if you get more than 10 correct and an extra £1 if you get more than 8 correct. You have 8 minutes to complete this.
- 2. Answer a multiple-choice quiz about broadband. You get £0.50 for each correct answer.
- 3. Fill in a questionnaire where you can give us your thoughts about the experiment.

We will pay you only once all of these have been completed BY ALL SUBJECTS. If you finish before others, please wait patiently.

Broadband background information

In the UK, fixed line internet services (broadband) are provided by ISPs (information service providers). The service that they provide can vary in several different ways. For example, the actual download or upload speed and the amount of data a customer is allowed to download per month typically varies from provider to provider.

In addition to speed (the rate at which data is delivered), there are some other considerations when choosing the appropriate package:

- Peak time data consistency: some ISPs may restrict the amount or speed of some types of traffic (e.g. file sharing) at some times of the day (e.g. peak times).
- Prioritization of real time services: some services require high levels of network responsiveness (i.e. no time delays). For example, online gaming or voice over IP services such as Skype would not work well if there was even a small delay between a user action and connection with the other users. Some ISPs may prioritize certain types of traffic to ensure that certain activities function as intended.

Usage information

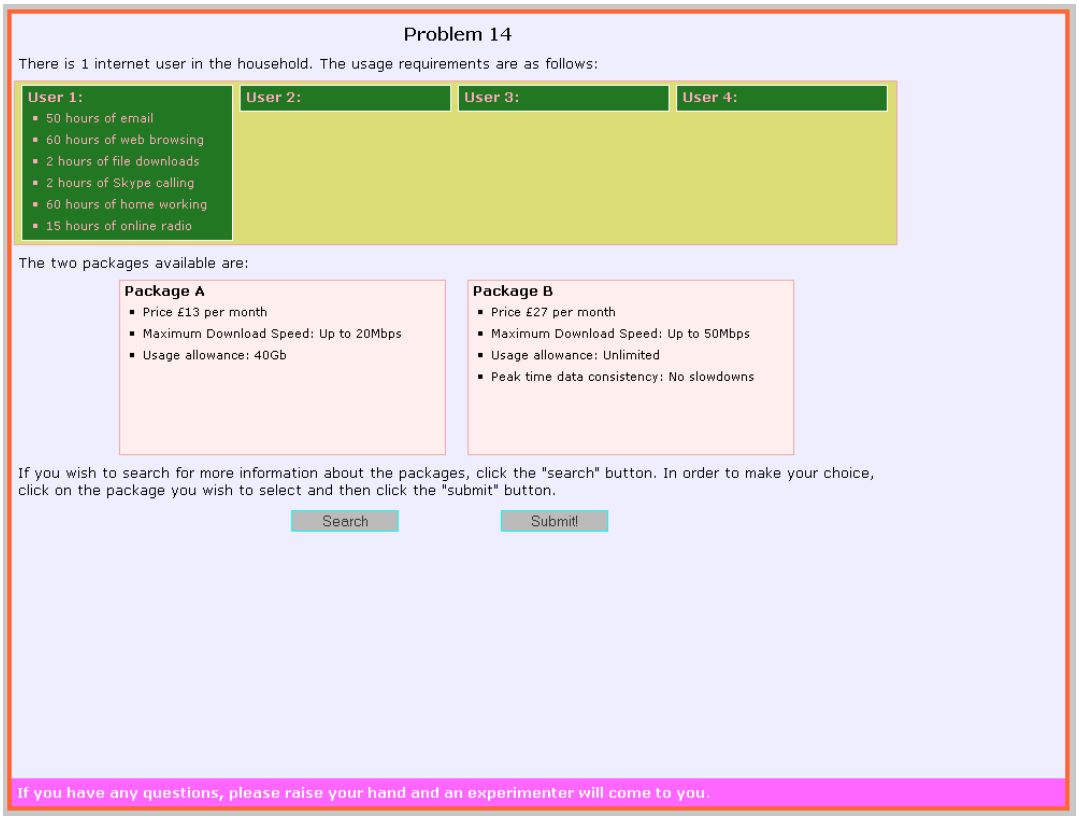
Different internet activities require different amounts of data and different network characteristics (e.g. download speeds, data consistency). The tasks you face will give you user profiles that detail the amount of time they spend on various internet activities. Here we list the activities and what they would consist of:

- Email: reading and sending email (including attachments).
- Web browsing: general web browsing (including Facebook, Hotmail, Online banking, IM etc).
- Youtube: viewing short, low quality, video clips.
- iPlayer HD (BBC programs): viewing high definition TV programs.

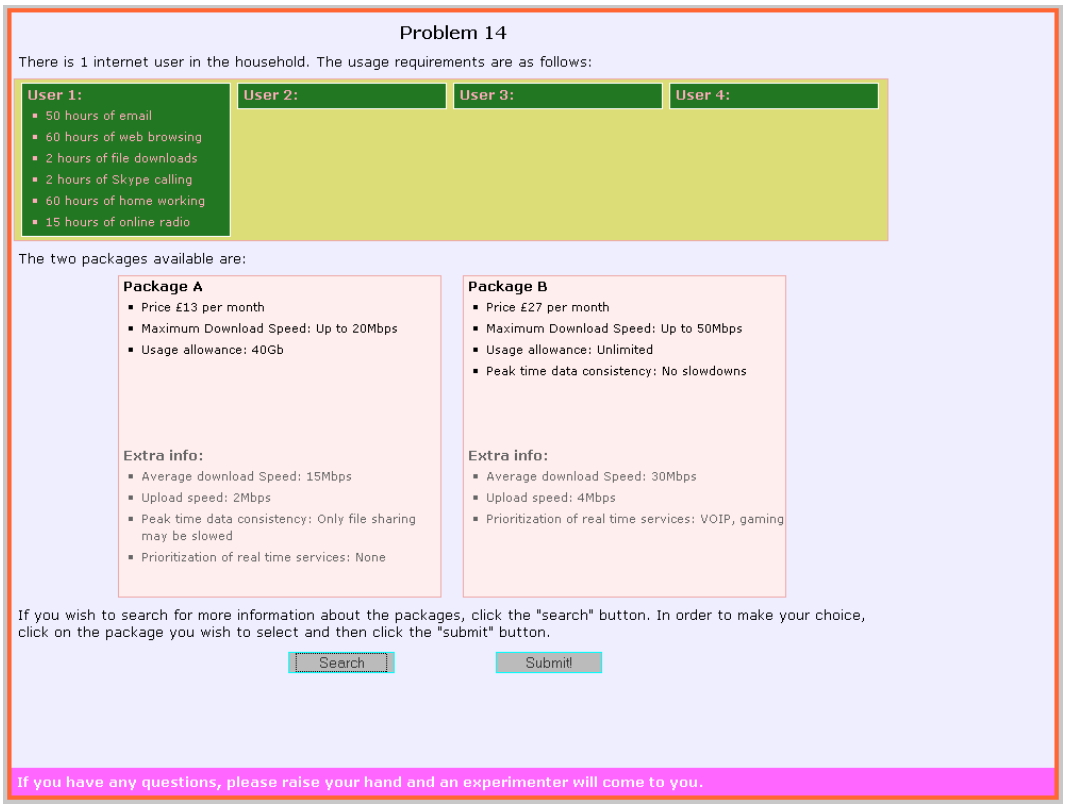
- File downloads: downloading music (e.g. iTunes), videos, software.
- Skype calling: video and voice calling over the internet ("voice over IP" / VOIP).
- Home working: working using remote desktop (e.g. WTS).
- Online radio: listening to online radio (e.g. BBC Radio 1).
- Online gaming: playing multiplayer games over the internet (e.g. Xbox).
- P2P file sharing: sharing files using P2P (e.g. BitTorrent).

END OF INSTRUCTIONS

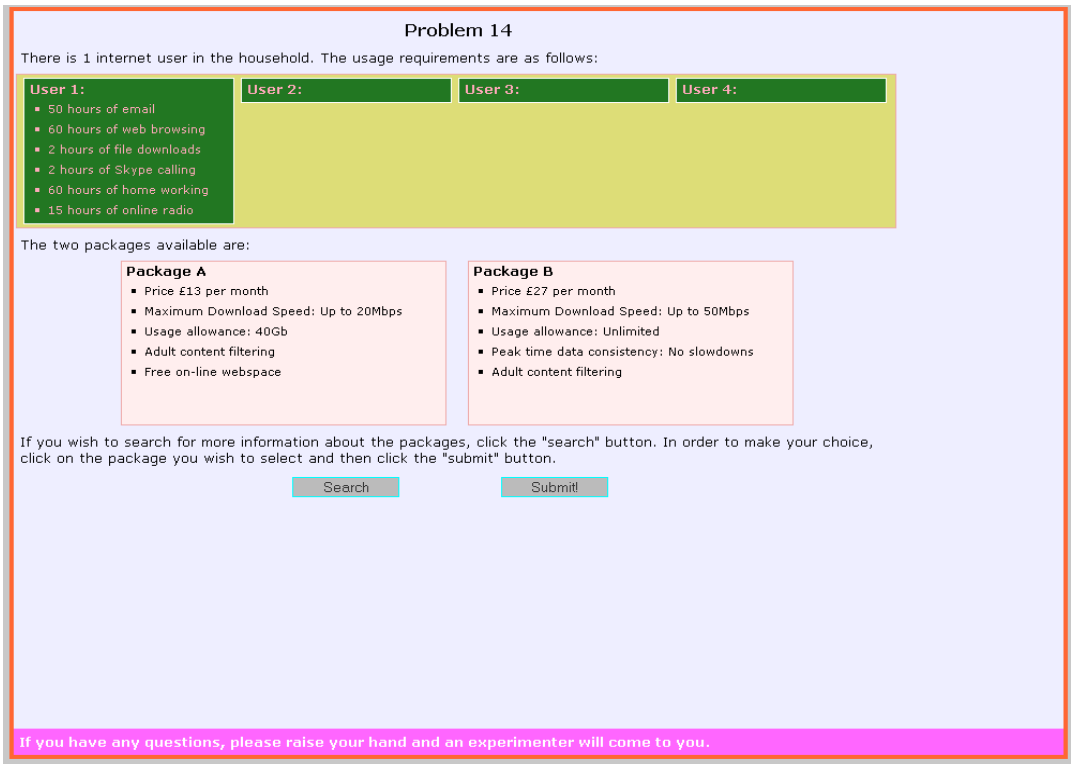
Annex 2 Experiment screen shots



Numerical coding with no superfluous information (headline information)



Numerical coding with no superfluous information (extra information)



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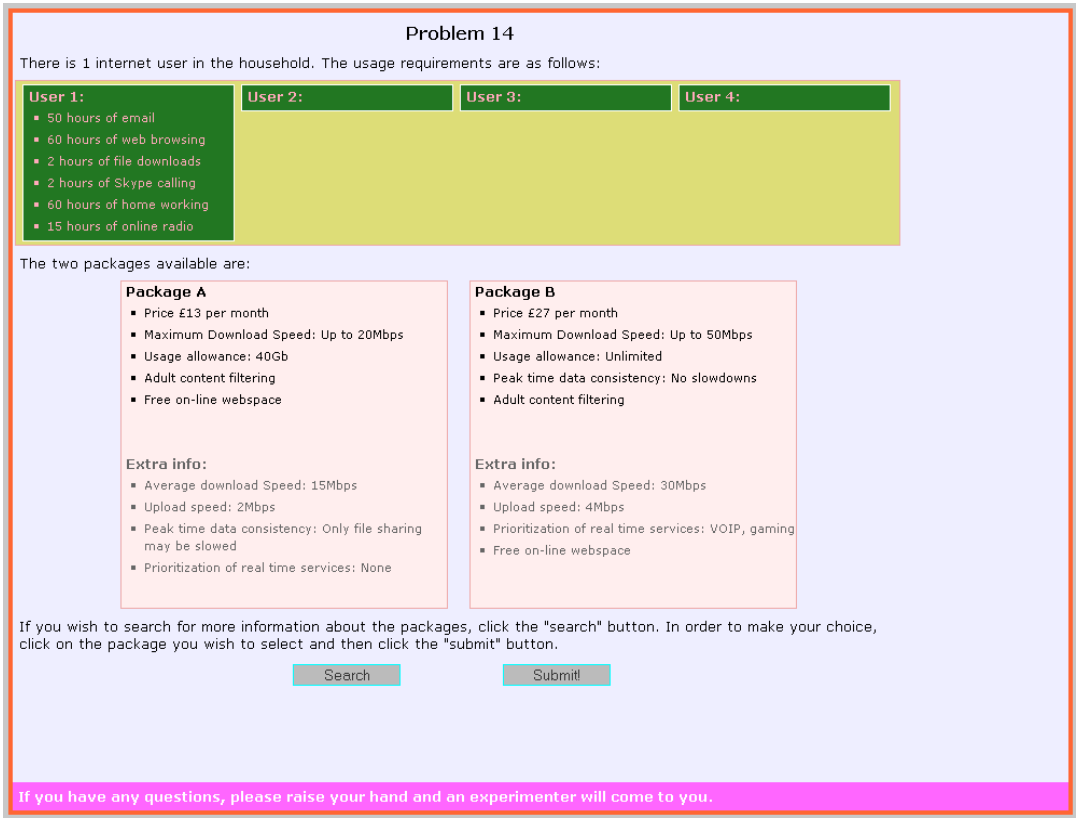
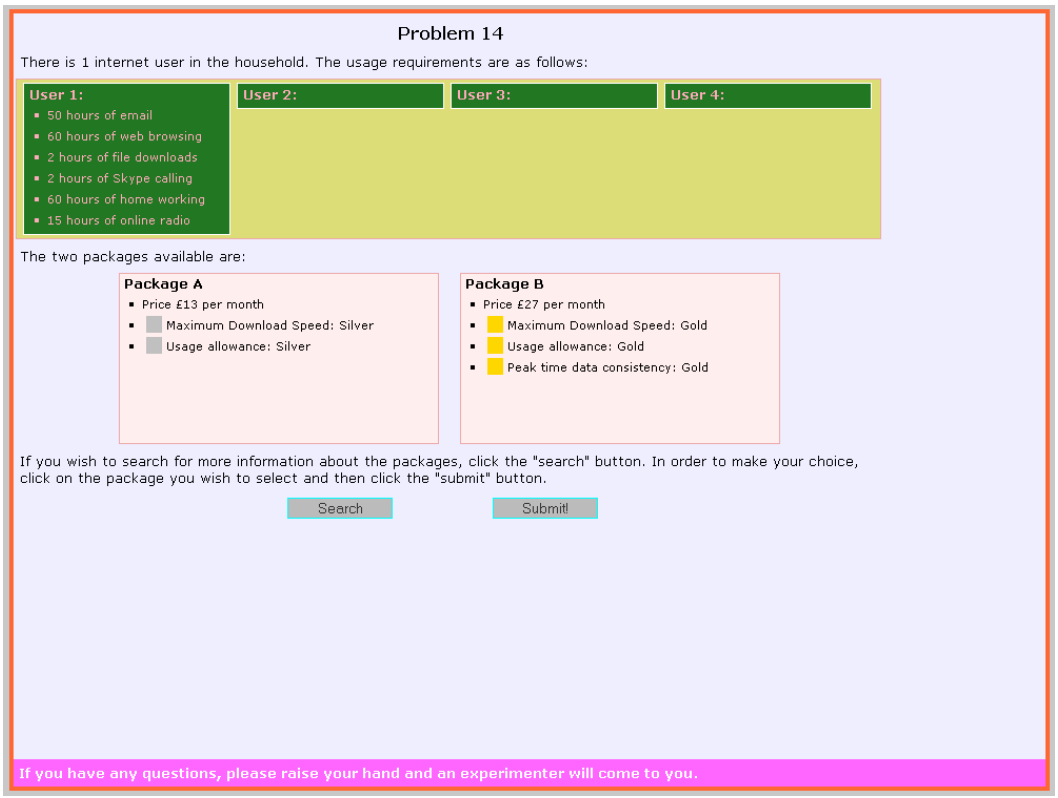
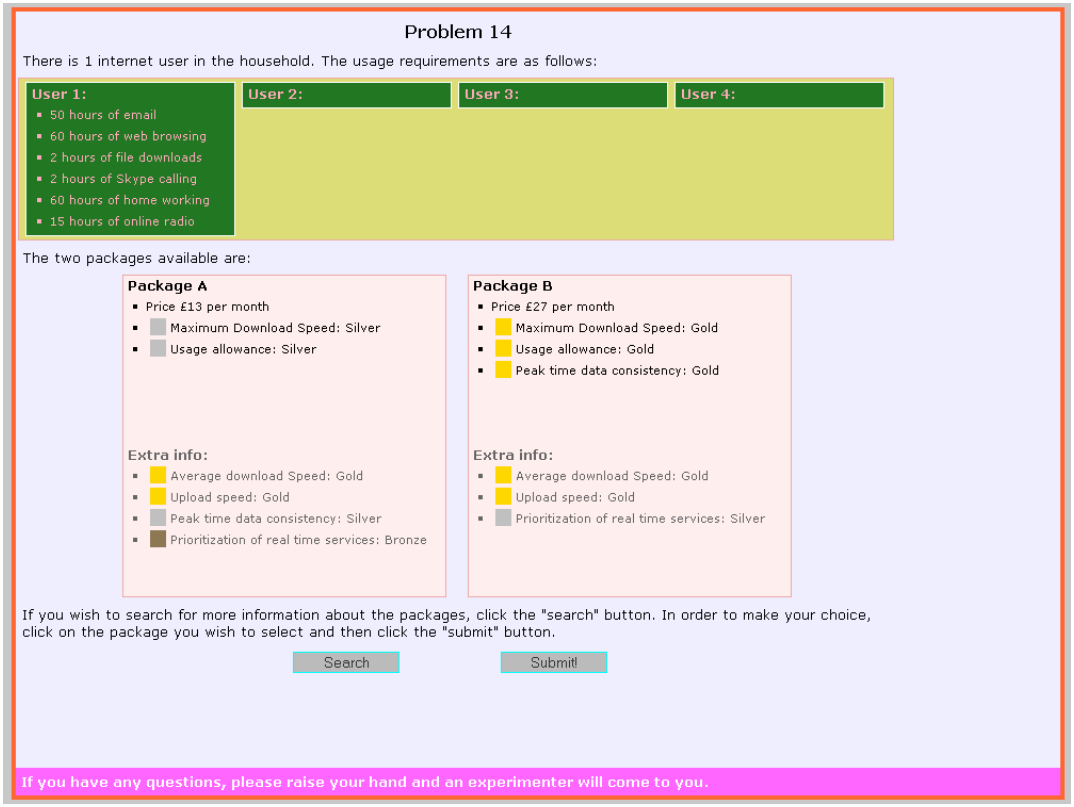


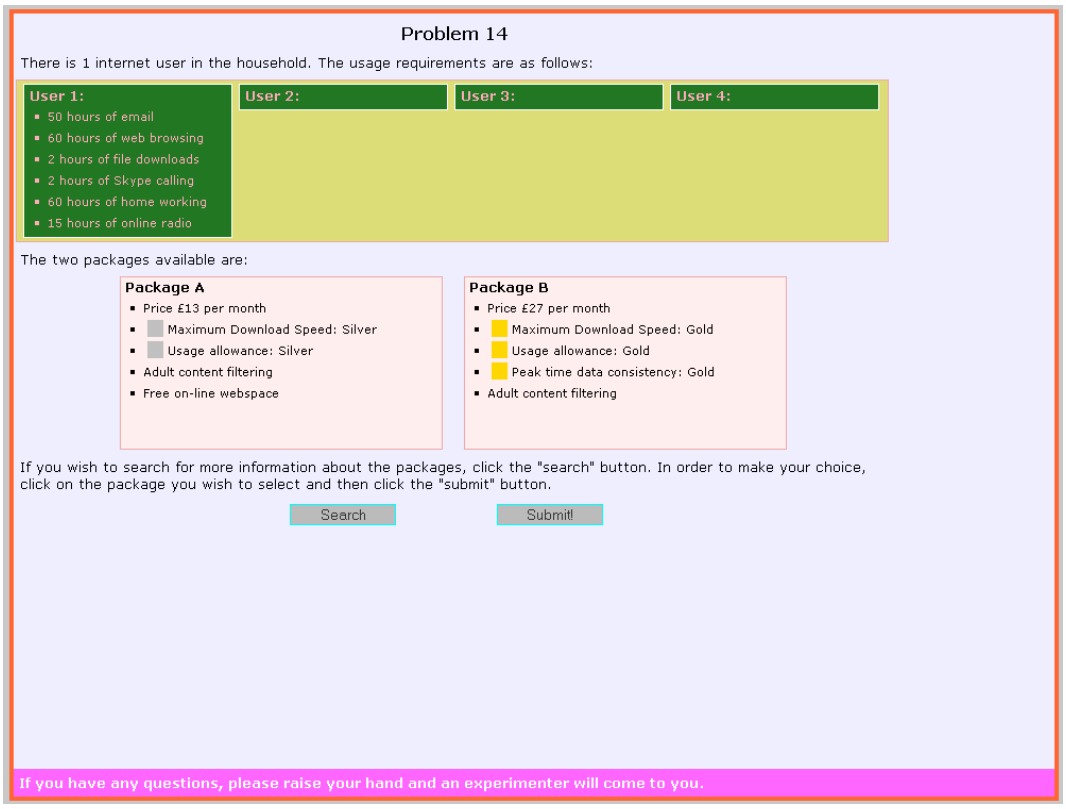
Numerical coding with superfluous information (extra information)



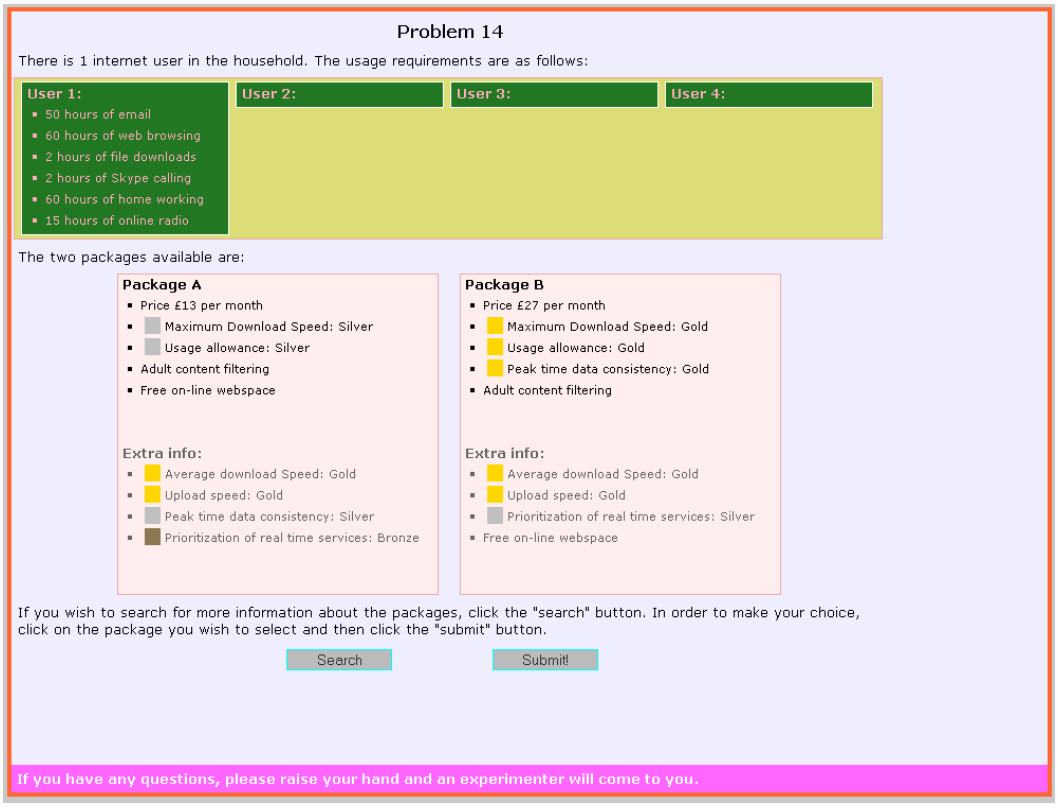
Colour coding with no superfluous information (headline information)



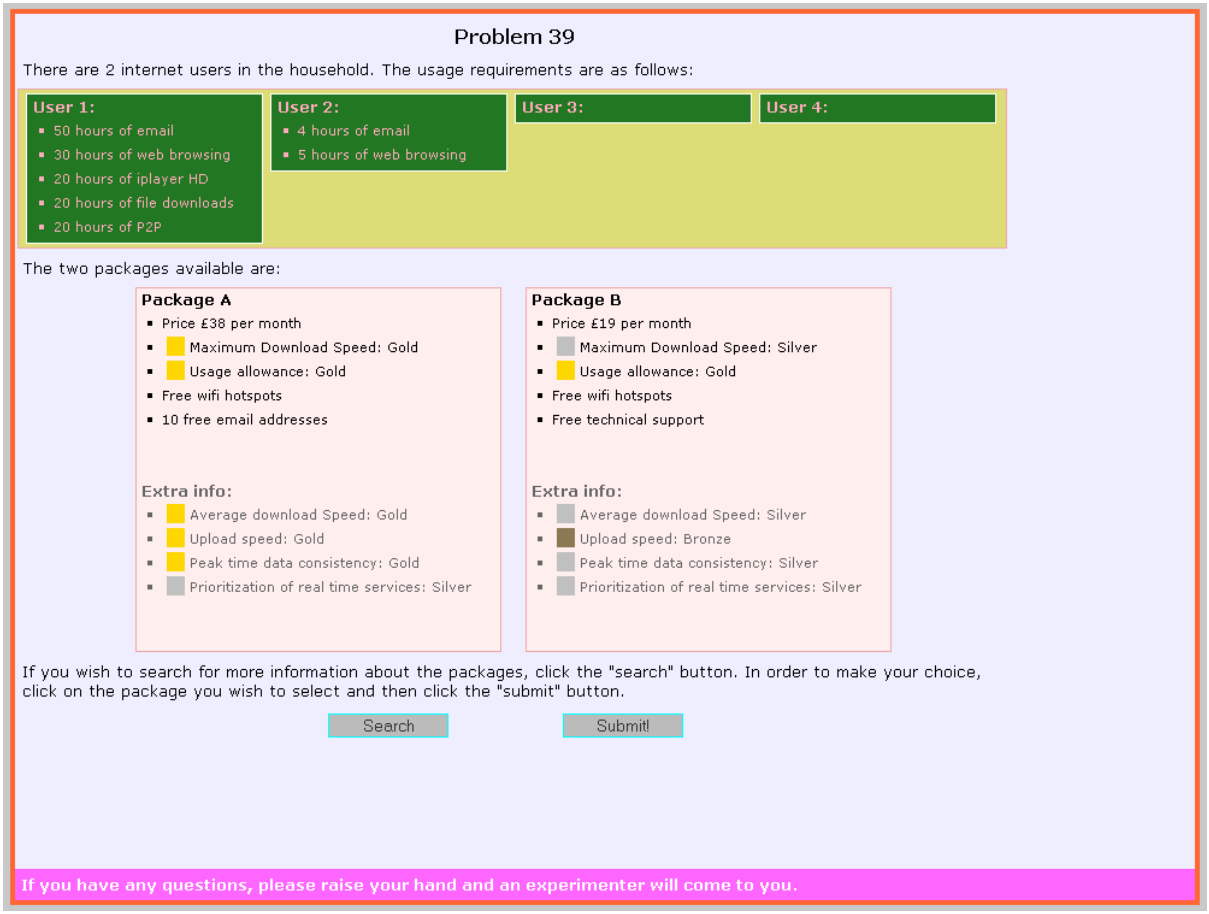
Colour coding with no superfluous information (extra information



Colour coding with superfluous information (headline information)

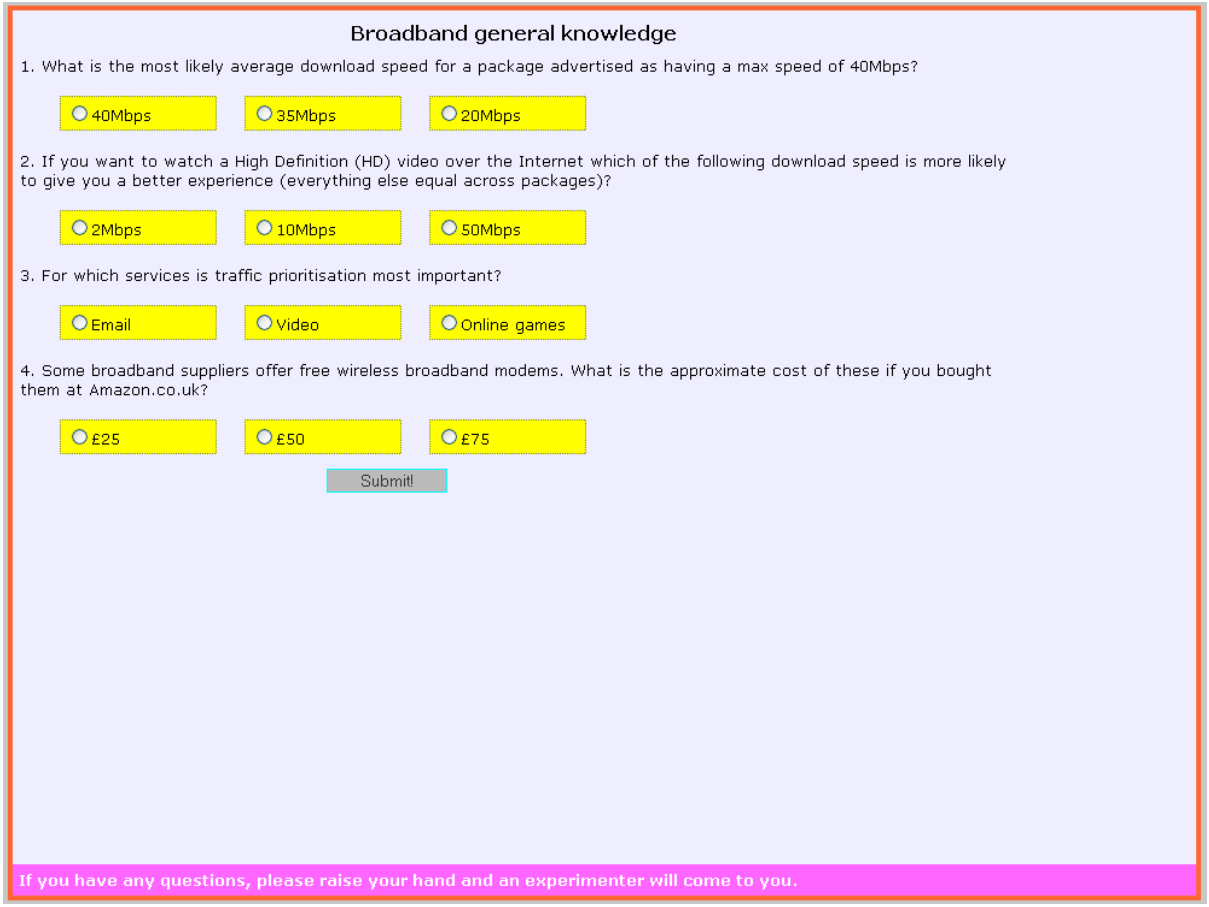


Colour coding with superfluous information (extra information)

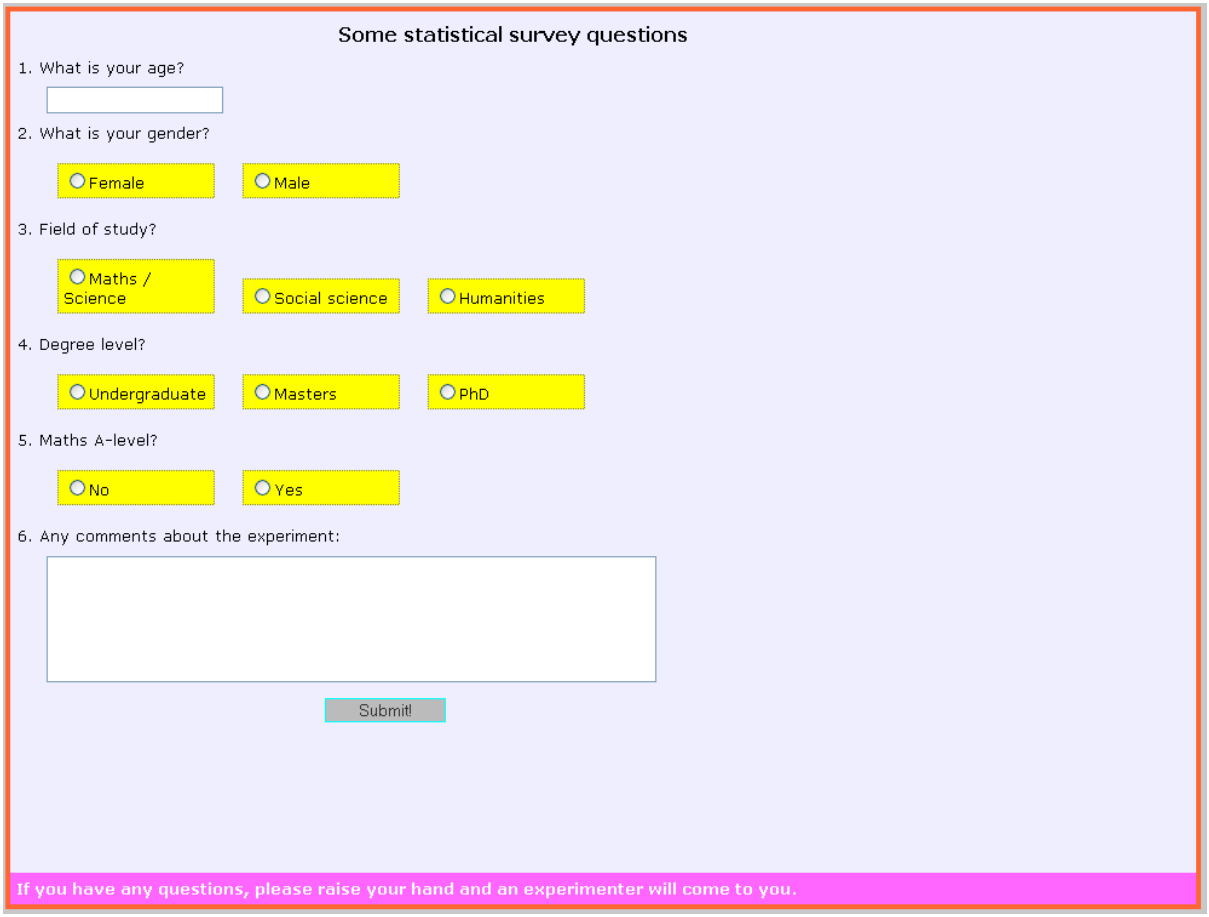


Multi user household problem

Annex 3 Broadband general knowledge test and personal characteristics



Screen shot of the general knowledge test



Screen shot of the personal characteristics questions