PERCEPTION, BEHAVIOUR AND COMMUNICATION IN RELATION TO RAPID ANTIGEN DETECTION TESTS – A NARRATIVE REVIEW OF EVIDENCE

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INTRODUCTION

Rapid Antigen Detection Tests for SARS-CoV-2 (hereafter RADT) are potentially a valuable tool in our response to the COVID-19 pandemic, but their usefulness depends on the perceptions, decisions and behaviours of those taking RADT. Successful implementation of RADT programmes requires people to take RADT and, importantly, to do so in line with public health advice. This implies a need for good general understanding of the situations in which RADT should and should not be taken. It also implies a need for people to understand what a test result means for them, since their interpretation of a test result may influence their subsequent protective behaviours. Clearly, if RADT are inappropriately used or the results are misinterpreted, this may result in an undesirable change in protective behaviours. In light of these issues, this paper presents a rapid narrative review of relevant evidence from behavioural science.

The paper addresses the following research questions:

RQ1: Do people (intend to) use RADTs in line with public health advice?

RQ2: Do people accurately interpret the meaning of test results?

RQ3: Do people adjust their behaviour following negative test results?

If problems are detected at any of these stages, solutions need to be designed to tackle them and to increase the chances of successful implementation of RADT screening programmes. Therefore, the last research question in this review is dedicated to solutions:

RQ4: Can people's judgements and (intended) behaviours be improved by more effective communication?

METHOD

To answer the above research questions, we first reviewed existing empirical evidence from the scientific literature on COVID-19 testing[1], including various types of tests used (PCR, RADT,

[1] Although the relevant tests aim to determine the presence of SARS-CoV-2, the virus that causes COVID-19, in this paper we refer to tests for COVID-19. We do this both because this is how the tests are generally referred to in ordinary language,

antibody). However, as this literature stream has been in existence for less than two years, it is quite limited. We therefore supplemented the evidence by looking also to the broader research literature on health screening and communication of risky health outcomes. This approach makes sense because the psychological mechanisms involved in responding to screening test results in general are likely to be involved in the response to tests for SARS-CoV-2.

The evidence related to the COVID-19 pandemic comes prevalently from Europe and also from the US. The methods used in the papers are surveys, qualitative studies and online randomised controlled experiments, usually with nationally representative samples. This last category of papers is crucial for the review as it helps to disentangle the mechanisms behind phenomena and allows for stronger causal inferences. For example, where experimental conditions differ by a single aspect, given successful randomisation, differences in behavioural response can confidently be attributed to that one aspect. Most research papers used in the review have been published in peer-reviewed scientific journals, however, we do include some pre-print articles as well, to get at the most recent findings. The broader health screening literature we cite consists of systematic literature reviews of existing empirical evidence combined with individual studies that deployed randomised controlled experiments, in line with the rationale supplied above.

UNDERSTANDING RADT AND WHEN TO USE THEM

Evidence on the general public's reasons for taking RADT is limited. Below we report on results from three surveys that asked people about this specific issue, one conducted in Germany between December 2020 and March 2021 (Betsch et al., 2021), one in the UK in June 2021 (Smith et al., 2021), and one in Ireland in August 2021 (Amárach, 2021).

When German citizens were asked to report why they had taken RADT, the most common answers in December 2020 were after travelling (20% of the sample) or contact with an infected person (21%), while in March 2021 it was for planned contact with a person at risk (34%), or planned contact with friends and family (21%). As for the intended use of point-of-care antigen tests in the future, the most common intentions were to use them in case of having symptoms (70%) and being in contact with an infected person (63%). Regarding RADT taken at home, the most frequent reasons for their use cited in open-text answers were to get certainty and reassurance (23%), to be able to meet close and vulnerable people (16%), to gain more personal freedom (15%) or to avoid infections in general (14%). In summary, the actual use of RADT in Germany was mostly before and after risky encounters and some use was explicitly linked to protective behaviours, while intended future use was to get reassurance about not being infected or check status in case of COVID-19 symptoms.

When UK citizens were asked about the government advice in case they had symptoms of COVID-19, 18% said they should take a PCR test, 10% a rapid test (the study centred on "Lateral Flow Tests"), and 60% said both of these were advised. These answers suggest that a majority of people see rapid and PCR tests as two alternatives with the same scope. Furthermore, people who had actually experienced symptoms were asked about what they had done and out of those who had taken a test, 53% said it was a PCR test, while 44% said it was a rapid test. Government advice at the time of the survey was that all adults should take RADT twice per week and confirm a positive result with a

including on government websites, but also because this is generally how they are referenced when communicating with participants in the behavioural studies that we cite.

PCR test, with RADT not to be used if experiencing symptoms of COVID-19. Hence, neither behavioural intentions nor actual behaviour were in line with government guidance.

In the Irish survey, just 48% of a representative sample knew that a "rapid antigen test" was less good than a "standard PCR test" at detecting whether a person has COVID-19. While 57% recognised that a benefit of RADT was that they could be used to screen people before attendance at activities or events, 36% thought that RADT were a quick way for people with symptoms to get tested and 27%) thought they were a convenient way for someone to make sure they don't have COVID-19. Ideally, individuals who take RADT would also be exposed to guidance when they take the test, such that they will be better informed than the public in general. However, the survey data found that those who had taken an RADT prior to the survey were, in fact, more likely to think that RADT are as sensitive as PCR tests and offer a quick way for someone with symptoms to get tested.

The above results suggest widespread misconceptions about RADT. Substantial proportions of the public in all three countries where we have evidence specific to RADT do not understand the difference between RADT and PCR tests, including in relation to pubic health guidance for individuals experiencing symptoms of COVID-19. Where we have evidence of actual use of RADT, the misconceptions persist. This provides a clear answer to RQ1: many people presently do not use (or intend to use) RADT in line with public health guidance.

COMPREHENSION OF SCREENING TEST RESULTS

Before examining studies specific to testing for SARS-CoV-2, there are lessons from the pre-existing broader literature on screening tests that is relevant to RQ2 – whether people are likely to interpret results accurately.

Interpreting health screening test results

The true meaning of a positive or negative health screening test result is unclear for many people. This has been demonstrated repeatedly in the scientific literature on health screening, across studies that cover tests for many different diseases, interpreted not only by lay people but also by health professionals. The usual process in such studies is to inform participants about test characteristics, such as sensitivity and specificity, baseline prevalence of a disease, and a test result, before asking them to judge the post-test probability of having the disease. While hypothetical, such scenarios mimic real-world judgement tasks, whereby doctors and individuals have pre-test information similar to above and need to interpret the test result and take appropriate actions.

Two main problems in interpreting test results have emerged. The first is substantial minorities of people take the test result to indicate a certain outcome, i.e., interpret a negative result as proof of absence of the disease and a positive result as proof of presence of the disease, ignoring that screening tests are not 100% accurate. For instance, in one study where women were asked to consider the implications of a "normal smear test result", 43% thought this would mean that they definitely did not have cervical cancer (Marteau et al., 2001).

The second problem is that judgements of test accuracy are often poor even among those who understand that screening tests do not give results that are certain. Furthermore, this finding occurs not only among lay people, but among healthcare professionals too. Whiting et al. (2015) undertook a systematic review of 28 publications studying health professionals' assessments of post-test

disease likelihood, given test characteristics. The most common mistake when interpreting a positive result is to overestimate post-test disease probability. Overestimation is quite substantial (ranging from 46% to 73% across individual studies) and imprecision is widespread (ranging between 0% and 61% of study participants). Fewer studies focus on negative results, but the main finding is that people's judgements of post-test probabilities of disease are poor.

Whiting et al. find that such misjudgements arise despite the fact that health professionals show a good understanding of test accuracy measures – how sensitivity and specificity are defined. The implication is that assessment of conditional probability may be to blame, in line with broader behavioural work on intuitive departures from the veridical application of Bayes Theorem across multiple domains. For instance, one study invited doctors to judge the same scenario, but randomly assigned them to groups with different base rate information (ranging from 1% to 95%). The majority provided the same answer (overestimating the post-test probability in most cases) regardless of the base rate (Agoritsas et al., 2010). A study undertaken in a different setting found a somewhat different picture, with post-test probabilities relying solely on base rate (19% of the sample) and also test sensitivity (27%) (Bramwell et al., 2006). The common feature is failure intuitively to integrate probabilistic information.

The broader screening literature therefore contains important lessons for how people are likely to interpret RADT test results. A substantial minority are likely to treat them as definitive. Furthermore, since the prevalence of disease and sensitivity of the test both must be considered, intuitions about the likelihood of having COVID-19 are likely to be poor, including among health professionals.

Interpreting COVID-19 test results

A small number of research studies produced during the current pandemic have looked at people's understanding of results of different types of tests – PCR, RADT and antibody[2]. On the positive side, evidence from these studies shows some basic understanding of tests and their results. For instance, people seem to know that COVID tests have higher specificity than sensitivity and they judge that low viral loads should mostly cause false negatives, while technical characteristics of a test or human error mostly false positives (Pighin & Tentori, 2021).

However, the two established problems with the interpretation of screening test results presented in the previous subsection have also been found in the context of COVID-19. Studies generally require people to consider getting a COVID-19 test, give further contextual information (e.g. pre-test probability of being infected) and ask them to make a judgement on the post-test probability of infection. Again, although such tasks are hypothetical, they reflect the real-world judgement process well.

Substantive minorities of people think that COVID-19 tests provide a sure result. When people were given a scenario consisting of an asymptomatic mass testing event with RADT and a negative result, almost half of them (45%) thought this meant they were definitely not infectious (Batteux et al., 2021). In a different study, people were asked to consider a symptomatic individual with a clinically-assessed 50% likelihood of having COVID-19. In a control group not subject to intervention, one-in-five experimental participants gave a categorical answer (0% or 100%) for the likelihood that this person had the disease given a negative or a positive PCR test (Recchia et al., 2021). Among people

[2] Although antibody tests differ from the other two in ultimate scope, the psychological mechanisms that affect people's interpretation of the results are likely to be very similar, since all these tests aim to detect the presence of something specific in the body, and give a simple yes/no answer with a degree of uncertainty.

presented with a scenario in which they received a positive antibody test, 15% thought there was no risk whatsoever of getting infected in the future (Waller et al., 2020).

Studies focussed on COVID-19 tests also confirm the second problem of interpretation, i.e., the tendency to misjudge test accuracy in numerical terms. While different studies focus on different concepts (e.g. false negative rate, positive and negative predictive value) and on different test types (PCR or RADT), results confirm that people overestimate the false negative rate (Betsch et al., 2021), underestimate the negative predictive value (Pighin & Tentori, 2021), and misjudge the likelihood of having the disease given a positive result (Pighin & Tentori, 2021; Betsch et al., 2021).

To summarise, evidence from studies specific to COVID-19 corresponds with findings from the broader health screening literature. People struggle to interpret screening test results. A substantial number of people continue to interpret probabilistic results as certain, while judgements of subjective post-test probabilities of having the virus are inaccurate. As with RQ1, the answer to RQ2 is hence also clear: people do not interpret test results accurately. An important point to note is that this finding is likely to apply to health professionals also.

BEHAVIOUR CHANGE AFTER A NEGATIVE TEST RESULT

Changing risky lifestyle behaviours after a negative health screening test

It has been proposed in the literature that a health screening test may result in a sense of false reassurance, a phenomenon also called *"certificate of health effect"* (Cooper et al., 2017). In particular, if people receive a negative health screening test, they may feel reassured that they do not and will not suffer from the relevant disease, and hence engage less in behaviours that would protect them (Cooper et al., 2017).

Empirical evidence on this specific issue is limited and mixed, however. A review of randomised controlled trials (Cooper et al., 2017) comparing people who get a negative screening test result for diseases linked to lifestyle behaviours to those who do not get screened at all found that only a minority of studies recorded statistically significant results. In fact, only one study included in the review (Berstad et al., 2014) shows a detrimental effect of a negative test result on lifestyle behaviours. A majority of studies also failed to record statistically significant effects on other possible indicators of false reassurance following a negative test result, such as worry or anxiety, perceived risk of a disease or self-reported health. Those that do find significant results, however, suggest a slight decrease in perceived risk or worry about the disease, in line with the idea of false reassurance.

In summary, current empirical evidence for false reassurance after negative health screening tests, in general, is weak. Given this limited evidence, definitive conclusions on the existence or non-existence of the phenomenon should not be drawn.

Changing protective behaviours after a COVID-19 test

It is easy to see how feelings of false reassurance could apply to the COVID-19 context. A negative test result might be interpreted as a sign that everything is fine and may lead people subsequently to let their guard down. Negative results could also act as a form of feedback on previous protective behaviours, confirming that they were sufficient to prevent infection. If we assume that these behaviours are costly (perhaps socially as much as financially), individuals may try to relax them a bit

after "successfully passing" the COVID-19 test, in an attempt to decrease the costs and find an optimal level of effort needed to prevent infection.

Qualitative evidence from universities in the UK (French et al., 2021; Wanat et al., 2021) finds that most students understand that RADT results should be taken with some caution and do not self-report changing their behaviour after a negative result. However, some do admit that the test results reassured them and had an effect on their subsequent decisions about meeting other people.

Quantitative evidence from the UK records high intention to continue protective behaviours after a hypothetical negative RADT (Batteux et al., 2021). Measured on a scale from 1 to 7 (very unlikely to very likely to engage in a behaviour), all protective behaviours of interest (mask wearing, hand washing, social distancing, avoiding meeting others, working from home and avoiding public transport), had a mean score higher than 6. There was no statistically significant difference in the behavioural intentions of participants who thought a negative rapid test meant no risk of being infectious and to those who correctly thought there was some residual risk (Batteux et al., 2021). However, in addition to involving only a hypothetical scenario, this null finding may have been due to a *"ceiling effect"*, whereby scores are too close to the maximum for reliable detection of differences between groups.

Further quantitative evidence from randomised experiments shows: (i) no effect of imagining getting a negative RADT test on intentions to follow government guidelines in the UK compared to a control group not being asked to imagine anything (61% vs 63% in the two groups, respectively), but lower intentions to follow the guidelines if the negative test is accompanied with a certificate (56% vs 63% in the control group) (Drury et al., 2021), and (ii) marginally lower intentions to wear a face mask (and no effects for other protective behaviours) for a social gathering in Germany if everyone had tested negative using a home RADT, compared to a situation in which testing status of the other participants is unknown (Betsch et al., 2021).

Just as reported engagement in protective behaviours is generally high, the hypothetical likelihood of engagement in risky behaviours has been found to be low, at least in a study conducted in the US, asking people to imagine being symptomatic (Zhang et al., 2021).[3] Whether without a confirmatory COVID-19 test or after such a test, the mean score is below 2 on a scale from 1 to 7 (extremely unlikely to extremely likely to engage in a risky behaviour) (Zhang et al., 2021). However, compared to a situation in which COVID-19 testing is unavailable (so the study participants are asked to imagine they have symptoms and have been diagnosed with COVID-19 by a doctor), participants randomly assigned to a group imagining getting a positive confirmatory test result are less likely to engage in risky behaviours, and vice versa for those told about a negative confirmatory test result (Zhang et al., 2021).

A further caveat to the above findings is the possibility that they suffer from *"social desirability bias"*, whereby people report behaviours untruthfully, overstating engagement in desirable behaviours in order to look better in other people's eyes (Furnham, 1986). In fact, social desirability bias has been demonstrated to skew reporting of protective behaviours by the public during the current pandemic (Timmons et al., 2020). This bias may inflate self-reports of protective behaviour and lower self-reports of risk-taking. However, in studies with a randomised design, social desirability bias does not offer an explanation for observed differences between groups.

[3] The measure of risky behaviours in this study was a score composed of scheduled activities (e.g. getting a haircut, attending a wedding), other potentially risky behaviours (e.g. getting public transport, visiting someone) and COVID-19 protective behaviours (e.g. wearing a face mask, self-isolating in case of symptoms).

In summary, it is difficult to draw definitive conclusions about behaviours after negative RADT based on currently available evidence. There are some relatively weak findings implying that behaviour may be affected after a negative test. But the evidence is quite scarce[4] and limited in scope, both in the specific context of COVID-19 tests and the broader screening literature. As well as recording intentions rather than actual behaviour, the focus is largely on protective actions, such as mask wearing or social distancing; evidence is lacking on social behaviours, such as meeting more people. Hence, the lack of strong evidence should not be taken as an indication that the answer to RQ3 is that people do not adjust their behaviour following negative test results.

IMPROVING JUDGEMENTS ABOUT SCREENING TEST RESULTS VIA EFFECTIVE COMMUNICATION

A modest volume of research seeks solutions to problems identified above by aiming to adapt or enhance communications surrounding tests. The focus is on possible ways of to improve people's understanding of test results and what this might mean for subsequent behaviour.

Understanding the uncertainty in health screening results

One of the main problems that we identified in interpreting health screening test results generally is that substantial minorities of people see them as revealing certainty about their disease status. One simple way to try to correct this belief is to state directly that there is uncertainty when results are communicated. There is some evidence that this is partially effective. For instance, 43% of women in the control group of a randomised experiment about understanding smear test results thought they definitely did not have cervical cancer after a "normal" result was announced. But in the treatment group, where the result was accompanied by a statement admitting uncertainty (*"you are at low risk of having or developing cervical cancer in next five years"*), only 26% thought so (Marteau et al., 2001). This simple explanation also helped to increase the proportion of women with a correct understanding of future implications of the test result on their health (from 56% to 69%) and decrease the likelihood of not knowing what the future implications were (from 41% to 23%). It may be important to keep such communications short and simple, however. Adding further numerical information to the uncertainty statement had no effect.

Understanding the uncertainty in COVID-19 test results

A similar intervention has been tested in several randomised experiments in the COVID-19 context, with some success. In one study (Batteux et al., 2021), when participants were presented just with a negative result from an RADT, only 54% of them understood that there was still some risk of being infectious. This increased to 71% if the simple phrase *"it's likely you were not infectious when the test was done"* was added to the result, and to 89% if the statement further specified that *"there is still a chance you may be infectious"*. Again, however, adding numerical information in form of an infographic did not further enhance understanding. Using a similar study design, Recchia et al. (2021) presented people with a scenario in which a symptomatic individual with a 50% likelihood of

[4] There is further existing research on behaviour change in the COVID-19 context, linked to changes due to a positive antibody test or after vaccination, measuring also real-world behaviours. However, we do not report the results from this research in the current review, as the psychological mechanism behind the change in behaviour may be different. Vaccination and antibody tests provide information on one's status that is more durable and potentially telling for the future, while PCR and antigen tests just provide information on the current situation.

having COVID-19 received a PCR test. When asked to assess the likelihood that the person had the disease given the test result (negative or positive), 20% of the sample gave a categorical answer (0% or 100%). However, when information about PCR tests included explanations of uncertainties about accuracy, only 6% produced a categorical answer

Subtle expressions of uncertainty in terminology can be influential. For instance, in a study centred on antibody tests (Waller et al., 2020), when what was being tested for was called *"antibodies"*, 10% of a sample thought that a positive test implied no risk of getting the disease in future. But when what was being tested for was called *"immunity"*, almost twice as many (19 %) thought they were at no risk.

The danger is that those who view test results as certain will be less inclined to undertake precautionary behaviours. Communicating uncertainty may therefore help to promote protective behaviours through better understanding of test results. Empirical evidence on behavioural impact is limited. One recent study recorded a small increase in caution when a negative RADT was accompanied by an explanation of uncertainty (Betsch et al., 2021). Another found that providing information about uncertainty in testing led to more caution when deciding whether a symptomatic individual with a negative PCR test should self-isolate (Recchia et al., 2021).

Improving accuracy in numerical judgements of post-test disease probabilities

As identified above, even when uncertainty is accounted for, judgements of post-test probabilities of having the relevant disease are inaccurate. However, the level of accuracy may depend on how the information is presented. For instance, when natural frequencies were used (e.g. *"100 babies out of 10,000 have Down's syndrome"*) for a randomly selected group of study participants, 24% of them provided a correct numerical estimate of the post-test probability of having Down's syndrome given a positive pre-natal test. When percentages were used instead (e.g. *"1% of babies have Down's syndrome"*), just 6% answered correctly (Bramwell et al., 2006). This superiority of natural frequencies compared to percentages has been repeatedly confirmed (Whiting et al., 2015), including with respect to the time health professionals take to make such judgements. Infographics can further enhance the positive effect of natural frequencies (Whiting et al., 2015).

To conclude, the answer to RQ4 regarding the potential for interventions is affirmative. Evidence suggests that providing direct explanations of uncertainty linked to screening tests leads to better understanding. Use of specific terminology can also communicate different degrees of uncertainty. Expressing numerical information about test characteristics and disease prevalence using natural frequencies leads to better estimates of post-test disease likelihood. Evidence for the influence of these interventions on behaviour is relatively weak, but this may reflect difficulty of measurement and should not be taken to imply that there is no such influence.

DISCUSSION

In this evidence synthesis, we reviewed literature relating to behavioural aspects of RADT during the current COVID-19 pandemic. Given the relative scarcity of research specifically focusing on our research questions, we also discussed relevant findings from the larger body of evidence about behavioural responses to health screening more broadly.

Several important findings stem from this review. The first concerns the public's use of RADT. While optimal use continues to be debated by experts around the world, the superiority of PCR tests for those experiencing symptoms is widely recognised. However, **a large proportion of the general public does not understand the essential differences between RADT and PCR tests, with many people intending to use RADT if they get symptoms or thinking both types of tests are similarly sensitive and suitable in such a situation.** It is important, therefore, that general public health communications and statements provided alongside testing programmes repeatedly and simply explain how the two types of tests differ and when RADT are appropriate.

Secondly, people's interpretation of test results suffers from misperceptions. The majority of people seem to understand that COVID-19 tests have a margin of error and that both false positive and negative results are possible. However, **a non-negligible minority of people incorrectly interpret test results as implying certainty about their disease status.** The main danger in the COVID-19 context are the false negatives, which, if not understood properly, may give false reassurance about not being infectious and possibly lead to riskier social behaviours.

Despite this relatively poor understanding of test results, **there is not strong evidence that people are likely to change protective behaviours following negative RADT, although this should not be taken to imply that behaviour will not be affected.** Obtaining persuasive evidence on this issue either way is challenging. Measuring real-world behaviours is hard and costly, while measuring behavioural intentions may result in misreporting. Given the presently weak available evidence and strong evidence on misconceptions surrounding RADT, some impact on behaviour remains quite probable. Research on how subjective probabilities of having the virus in general affect behaviour could be useful.

Fortunately, minor changes in how information about RADT is communicated are likely to improve comprehension. **Simple statements that directly communicate residual uncertainty about disease status need to be expressed when tests are administered and when results are provided, while terminology that has connotations of certainty should be avoided.** Assessments of the probability of having (or not having) the virus following RADT are nevertheless likely to be inaccurate and such inaccurate judgements are also likely to be prevalent among health professionals. Understanding is helped when information is presented as natural frequencies rather than percentages.

Based on the evidence available and reviewed here, we would suggest that all agencies that seek to undertake RADT programmes should check the language that they use to describe RADT in general communications to those taking part in the programmes and, perhaps particularly, in communication surrounding test results. **Evidence supports a simple, clear message accompanying communication of a negative RADT test, stating that it remains possible that the individual is infectious.** Where results are uploaded to an online system, a similar message could also appear.

Overall, this review of literature suggests that human judgements and behaviours are likely to be important to the successful implementation of RADT programmes and supports some specific interventions to address the identified problems.

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