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Cognitive decision strategies adopted by trained judges in reminder difference tests when tasting yoghurt, mayonnaise, and ice tea

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ABSTRACT

Decision strategies used by judges to discriminate between three different food products (ice tea, yoghurt, and mayonnaise) are investigated using two standard tasks (A-Not A and 2-AFC) and their reminder equivalents (A-Not AR and 2-AFCR). Previous research with model solutions of varying complexity suggests that the strategy adopted in the A-Not AR task is judge-dependent, with little consistency evident across judges for a particular stimulus type. For 2-AFCR, the β- and τ-strategies, were more consistently adopted across all solution types. As food products are naturally more complex than model solutions, it is hypothesized that a more consistent use of decision strategies for the reminder tasks will be evident across judges. This is because auditory and visual research has indicated that more optimal decision strategies can be adopted as stimulus complexity increases, and the β-strategy produces optimal performance in the A-Not AR task, and the β- or τ-strategies result in equivalent optimal performance in the 2-AFCR task. Results are consistent with this hypothesis. For the A-Not AR task the β-strategy was adopted by most judges, and for the 2-AFCR task the β- or τ-strategies were adopted by most judges. This occurred for all three products. Additionally, the A-Not AR task was found to have higher test sensitivity than the other three tasks investigated, each of which had similar test sensitivity. These results lead to greater confidence in the use of the reminder tasks, in particular the A-Not AR task, for routine sensory difference testing with real-world products.

1. Introduction

Sensory difference tests are employed by the food science industry to determine whether sensory differences exist between taste stimuli. If sensory differences do exist, these tasks can determine the degree of difference perceived by judges. Not all tasks are equal, that is, some tasks are quicker to set up and for judges to complete, and some tasks are more sensitive to stimulus differences than others. These are important issues for the food industry where it is necessary to minimize the costs involved in testing, which can be done by employing the most suitable task for the purpose of the investigation.

To capitalize on any differences between stimuli, judges need to apply a rule during their decision-making. This rule is known as a decision strategy. For example, a judge may be asked to respond 'yes' if a sugar solution is presented and respond 'no' if water is presented. This example describes the yes–no task of psychophysics (Macmillan & Creelman, 2005, p. 17), or the A-Not A task of Food Science. To make a response, the judge sets a criterion at some point along the sensory continuum arising from the available stimuli. When a stimulus is presented and it is perceived as greater than the criterion, the judge responds 'yes', otherwise the response is 'no'. This is known as the likelihood-ratio decision strategy in psychophysics (Green & Swets, 1988, p. 10; Macmillan & Creelman, 2005, p. 33). In the food science literature, the two most frequently reported decision strategies are the beta decision strategy (β-strategy), identical to the likelihood-ratio decision strategy just described, and the tau decision strategy (τ-strategy), which is known as the differencing decision strategy in psychophysics (Macmillan & Creelman, 2005, p. 181). In general, for the β-strategy a judge sets a β-criterion and the decision is based on whether the sensory evidence arising from the stimulus is greater or less than that criterion. For the τ-strategy, a judge sets a τ-criterion (a perceptual difference between stimuli) and the decision is based on whether the difference between the sensory evidence arising from the stimuli is greater or less than that criterion.

Recently there has been interest in a class of difference tests that use the reminder paradigm. In particular, the reminder versions of the A-Not A and 2-AFC tasks, denoted A-Not AR and 2-AFCR. The reason for interest in these tasks is that a constant

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reminder stimulus is presented on each test. This reminder stimulus may assist the judge in making a (correct) decision by priming memory at the beginning of each test with information about the reminder stimulus; usually the reference stimulus. Comparison of performance using various decision strategies available in the reminder tasks shows that using the reminder as a comparison stimulus in A-Not AR leads to performance that is worse than in A-Not A, whereas using the reminder in this way for 2-AFCR leads to the same performance as in 2-AFC (Hautus, van Hout, & Lee, 2009). There is also a possibility that the reminders are not used as comparison stimuli in a test, but rather, they simply serve to prime memory. This could lead to performance better than expected in the standard versions of these tasks.

Signal detection theory presumes that the sensitivity measure d' should be the same for different tasks (for the same judge, decision strategy, and stimuli). However, in the real world, some tasks are more sensitive to stimulus differences due to factors not included in the detection-theoretic model for those tasks. In other words, some tasks have better test sensitivity than do others. For example, tasks having more than one stimulus per test (e.g., 2-AFCR) may be more fatiguing, have a greater memory load, and be prone to greater carry-over effects, compared to the A-Not A task (Lau, O'Mahony & Rousseau, 2004; O'Mahony & Goldstein, 1986; O'Mahony & Odbert, 1985; Stocks, van Hout, & Hautus, 2013). In the framework proposed by Bi and Kuesten (2012), test sensitivity is related to the validity of the estimate of d'. Test sensitivity, within this framework, focuses mainly on the component of validity related to the level of bias of the estimate when compared to the 'true' value.

A brief outline follows of the two standard tasks (A-Not A and 2-AFC) and their reminder equivalents (A-Not AR and 2-AFCR) with emphasis on the decision strategies available for each task. For the A-Not A task, one of two stimuli, 'A' (denoted *A*) or 'Not A' (denoted *B*) is presented on any given test. The judge needs to decide if *A* or *B* was presented. The β-strategy is the most discussed decision strategy available for the A-Not A task, however, a possible alternative strategy has been suggested (Santosa, Hautus & O'Mahony, 2011; Wichuchikit & O'Mahony, 2010). For the β-strategy, $d' = z(H) - z(F)$ (Green & Swets, 1988, pp. 15–23).

The A-Not A with reminder task (A-Not AR) is a variation of the A-Not A task. The A-Not AR task always starts with a reminder stimulus (e.g., *A*) and is followed by either an *A* or *B* stimulus, resulting in two stimuli being presented on each test. For the A-Not AR task, the β- and the τ-strategies are available. If the β-strategy is used, $d' = z(H) - z(F)$, the same as for the A-Not A task because the judge ignores the reminder stimulus. If the τ-strategy is used the judge uses the reminder stimulus in the decision making and considers the difference between the reminder stimulus and the second stimulus (i.e., *A* or *B*). The judge sets a difference criterion and responds 'B' (or 'Different') when the difference between the stimuli on a test exceeds the criterion, otherwise the response would be 'A' (or 'Same'). For the A-Not AR τ-strategy, $d' = \sqrt{2}\ (z(H) - (F))$ (Macmillan & Creelman, 2005, pp. 180–182). Note that while the responses 'Same' and 'Different' may be used in A-Not AR, this is not technically a same-different task. In the same-different task the first stimulus in the pair can be either *A* or *B*, leading to four possible stimulus sequences on a test. For A-Not AR the first stimulus is always the same, leaving only two possible sequences. The models and predicted performance for these two tasks are different.

Both *A* and *B* are presented on each test in the 2-AFC task. The judge needs to decide whether *A* was presented first or second. As for the A-Not AR task, both the β- and τ-strategies are available. However, for the 2-AFC task it is not necessary to know which strategy was used because they both result in the same d' estimate, $d' = (z(H) - z(F))/\sqrt{2}$ (Green & Swets, 1988, pp. 64–68).

The 2-AFC with reminder task (2-AFCR) is a variation of the 2-AFC task. The 2-AFCR task always starts with a reminder stimulus (e.g., *A*) and is followed by either *AB* or *BA* resulting in three stimuli being presented on each test. The judge may ignore the reminder, as can be the case for the A-Not AR task. When the reminder is ignored for the 2-AFCR task, the situation becomes the same as a 2-AFC task in which a β- or τ-strategy can be used, as discussed above. If the τ-strategy is used in 2-AFCR, the judge compares the difference between the reminder and the first stimulus with the difference between the reminder and the second stimulus. A neutrally biased judge will select the stimulus that produces the most negative difference from the reminder as being the same as the reminder, given that the reminder is the stimulus with the lowest average perceptual magnitude. Hence, the direction of the difference (i.e., reminder greater or less than the test stimulus in magnitude) is important to the decision. As for the 2-AFC task, it is not necessary to determine which of these two strategies is used because they both result in the same d' estimate; $d' = (z(H) - z(F))/\sqrt{2}$ (Hautus et al., 2009).

Another strategy available for the 2-AFCR task is the comparison of distances (COD) strategy. For the COD-strategy, judges compare the absolute difference between the reminder and each test stimulus. If the COD-strategy is used, the judge ignores the direction of difference, that is, whether the test stimulus is greater than or less than the reminder. For this reason, there is a loss of information and the decision is based solely on which test stimulus is the most similar to the reminder (Hautus et al., 2009).

Hautus, Shepherd, and Peng (2011a) used a cordial solution to determine the decision strategies adopted in the 2-AFCR task and found that all judges most likely used a β/τ-strategy. This consistent result was promising. However, Stocks et al. (2013), using aqueous solutions that differed in the number of dissolved basic tastants (citric acid, sucrose, sodium chloride, and caffeine), determined the decision strategies adopted in the A-Not AR and 2-AFCR tasks. Group results suggested the τ-strategy was used for the A-Not AR task for solutions consisting of two and three of the four compounds, although nine out of twenty cases suggested that the β-strategy was most likely used. Group results suggested that a β-strategy was most likely used for a solution consisting of all four compounds, although two out of ten cases suggested that the τ-strategy was most likely used. For the 2-AFCR task, group results suggested that the β/τ strategy was used, however seven out of thirty cases most likely used the COD-strategy. The relative inconsistency of these results, particularly for the A-Not AR task for two of the solution types, suggested that caution is required in the use of reminder tasks in general and the A-Not AR task in particular.

Complexity has been found to influence the decision strategy used by judges in the same-different task – at least in visual and auditory research – with judges using a τ-strategy for simple stimuli and a β-strategy for complex stimuli (Hautus, Irwin, & Sutherland, 1994; Irwin & Francis, 1995). While this has not always been the case for taste stimuli (e.g., Lee, van Hout, Hautus & O'Mahony, 2007b) perhaps the cordial used by Hautus et al. (2011a), deliberately constructed with several combined flavors, was more 'complex' than even the aqueous solution containing the most tastants that was used by Stocks et al. (2013). Alternatively, the cordial represented a truly multidimensional taste stimulus – a real-world stimulus – whereas the aqueous solutions had fewer multidimensional characteristics. If either of these statements is correct, and a β strategy is facilitated by the presence of more complex stimuli, then we would expect to observe the apparently inconsistent results reported in each of these studies.

Three different food products, ice tea, yoghurt, and mayonnaise, are used in the current study. These particular products were chosen primarily because they differed in texture: ice tea is a non-viscous liquid; yoghurt is a semi-solid dairy product; and