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Examining how motivation toward science contributes to omitting behaviours in the Italian PISA 2006 sample

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ABSTRACT

The present study explored the omitting behaviour of a sample of 15-year-old Italian students participating in a large-scale assessment, in relation to their scientific self-efficacy, scientific self-concept, enjoyment of science, general interest in science and instrumental motivation, taken as dimensions of their overall motivation to learn science. Statistical analysis was applied to the PISA 2006 data set collected from 21,773 15-year-old Italian students. The research aim was to evaluate the relation between missing responses and the Italian PISA 2006 science scores and to identify the presence of homogeneous subgroups of students displaying distinctive omitting behaviours. Cluster analysis identified three sub-groups of omitters: low, leavers and jumpers. Group membership was significantly related to a) different patterns and levels of student motivation to learn science and b) gender. The results also showed that Italian students' science achievement on PISA 2006 was negatively predicted by their rate of omissions. Furthermore, multinomial logistic regression analysis suggested that students' scientific self-efficacy and enjoyment of science had a significant effect on their omitting behaviours. In light of these findings, the implications for education and the value attributed to the PISA assessment are discussed.

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1. Introduction

International comparative assessments of student achievement, such as the Programme for International Student Assessment (PISA), are becoming increasingly important in the development of evidence-based education policy. The main purpose of large-scale assessments is to provide countries with both a means of assessing educational outcomes with respect to international standards and as detailed a picture as possible of the effectiveness of their educational systems. Given these aims, it is clearly critical to develop valid measures, and to pay due attention to how qualitative information is inferred from the estimates obtained. In a seminal work, Messick (1994) focused on the use of test scores, discussing both the short- and long-term consequences of how we interpret scores. According to his analysis, for a measure to be considered valid, low scores should not occur because the assessment fails to capture key aspects of the construct, thus preventing candidates from displaying their competences; nor should low scores occur because the assessment is partly irrelevant thereby failing to reflect candidates' true level of competence. Both of these threats to validity are usually taken into account in large scale the design of large-scale assessments, and major effort – underpinned by a detailed theoretical rationale – put into devising tests that cover the main facets of the construct being measured. Nonetheless, developing useful and meaningful measures to reflect a theoretical framework is a challenging task. Where large scale assessment is concerned, this task is a particularly sensitive one, and the choice of scoring rules and mathematical models for deriving quantitative variables demands careful evaluation. The consequences of these choices will influence the later interpretation of scores. Typically, final scores implicitly reflect psychometric features and respondent characteristics that influence the interpretation of outcomes at the population level. It follows that interpretation of the international student assessment programme (PISA) informing OECD country comparisons would gain from taking into account how specific omitting behaviours on the part of students might affect the validity of PISA results, or possibly undermine the grounds for assessing quality and equity of education outcomes. In a recent study, Babic and Baucal (2011) showed that PISA results are mainly determined by contextual factors, such as student motivation, and the level of support for the PISA study provided by different national educational systems, rather than representing a true measure of the quality of education.

This paper presents part of a research project currently being conducted on the Italian dataset from PISA 2006. PISA assesses the extent to which students near the end of compulsory education have acquired some of the knowledge and skills that are essential for full participation in society. The main focus of PISA 2006 was scientific literacy. The present study explored the influence of the amount of missing values

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on the Italian outcomes, also investigating selected dimensions of omitter students' motivation to learn science. The proportion of missing responses, and especially how omitted items are distributed throughout the dataset, can negatively affect estimates (Tabachnick & Fidell, 1996). Thus our research question was whether omitters constitute a different population, that would call into question the interpretation of the Italian test results. Usually, large-scale analyses such as PISA adopt one of two strategies in relation to omission: omitted responses are either treated as ignorable missing data, or it is assumed that all omitted responses indicate lack of competencies. However, recent research has shown that the traditional tendency to treat missing responses as wrong answers may be a source of bias (Glas & Piementel, 2008; Holman & Glas, 2005; Moustaki & Knott, 2000; O'Muircheartaigh & Moustaki, 1999; Rose, Davier, & Xu, 2010).

Despite the development of standard procedures for analysing item behaviour and candidate performance, very little is known about what actually goes on when a student encounters a test item.

Achievement in a test situation is influenced by factors internal to the student, as well as by the imposed features of the testing environment such as the test instrument itself and preparation for it. Internal factors comprehend both the student's socio-economic background and his or her psychological characteristics such as motivation and values.

1.1. Motivation to learn science in PISA 2006

Students' degree of motivation plays a significant role in the learning processes affecting their learning outcomes (Kornhauser, Minahan, Siedlecki, & Steedle, 2014; Pintrich & Schunk, 2002; Spinath, Eckert, & Steinmayr, 2014; Wigfield & Eccles, 2000; Wise & Smith, 2012). Numerous authors have observed that learning motivation impacts on students' conceptual change processes, critical thinking, learning strategies and school achievement (Pintrich, Zusho, Schiefele, & Pekrun, 2001; Kuyper, van derWerf, & Lubbers, 2000; Napier & Riley, 1985; Pintrich, 2003).

With regard to learning science in particular, previous research (Barlia & Beeth, 1999; Hynd, Holschuh, & Nist, 2000; Lee & Brophy, 1996) has identified specific factors influencing student motivation, including: students' own interest in the subject; students' interpretations of the nature of the task; students' success or failure to make progress in scientific understanding; and students' general goals in relation to scientific understanding. Taken together, all of this evidence suggests that the motivation to learn science is a multicomponent construct, as conceptualised in expectancy-value theory, EVT (Wigfield & Eccles, 2002; Pintrich, 2003). According to EVT, an individual's behaviour (motivation in the case of learning science) is a function of (a) expectancy (belief in one's ability to complete the task) and (b) value (one's appraisal of the value of a given task (Pintrich, 2003).

These motivation components can potentially influence the arousal, direction, and sustainment of students' science-learning behaviour.

For the purposes of the current study, therefore, we mapped motivational constructs measured by the PISA questionnaire on learning science onto some of the key constructs identified by EVT (e.g., Eccles, 2005; Wigfield & Eccles, 1992, 2000, 2002). Specifically, we selected three key components from the EV framework: expectancies, intrinsic value, and utility value. Expectancies are individuals' beliefs about how successfully they will perform certain tasks. We took the PISA scientific self-concept and self-efficacy items as a measure of these expectancies. Intrinsic value is the expected enjoyment of engaging in a specific activity or task and it corresponds to the PISA constructs of interest in and enjoyment of science. Utility value is the perceived usefulness of a task in relation to obtaining rewards or facilitating the achievement of other immediate or long-term goals, and may be viewed as equivalent to the construct of instrumental motivation assessed in PISA. In addition to these motivational components, we also examined the role of gender in predicting omitting behaviours. A number of recent studies comparing males and females in terms of their mean levels of motivation and interest toward mathematics and science have yielded contradictory results (Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002; Simpkins, Davis-Kean, & Eccles, 2006). Although at the mean level, gender differences in attitudes toward math and science seem to have become smaller or insignificant, gender differences still exist in how boys and girls prioritise math and science in relation to other school subjects (Chow & Salmela-Aro, 2011; Zilberberg, Finney, Marsh, & Anderson, 2014). Likewise, studies on test-taking motivation suggest that under low-stake conditions female and male students cope differently with test items, with male students displaying a lower level of effort (for a review, see DeMars, Bashkov, and Socha (2013)).

1.2. Omitting behaviour of Italian students in PISA 2006

The tendency to omit items has been a cause for educational concern. Previous studies have shown that students often omit items even when they are taking a high-stakes test and know that they will not be penalised for guessing or providing incomplete answers (Grandy, 1987). Matters and Burnett (2003) investigated relationships between the tendency to omit short-response items and psychological factors.

They found that students were more likely to omit items when they had a poorer academic self-concept, lower self-estimated ability, lesser achievement motivation and greater interference from test-irrelevant thoughts. Conversely, students who are motivated to learn science and engage in science-learning behaviour pursue goals such as good science grades and science-related careers (Bryan, Glynn, & Kittleson, 2011).

Pintrich and De Groot (1990) argued that in school-based learning contexts, students' affective or emotional reaction to tests and examinations is a further key dimension of motivation.

The non-consequential nature of the PISA assessment may affect students' strategies in approaching the test items. Debate has focused on whether students sitting low-stakes tests for the purposes of international comparative studies are poorly motivated to perform well in them (Sessoms & Finney, 2015; Wise & DeMars, 2005). Studies on item omission and students' psychological characteristics (Matters & Burnett, 2003; 1999) have consistently shown that omitting behaviours are related to a series of factors that include personality, perceived difficulty of the task (or item), test preparedness, and features of the assessment situation (e.g., time limit, test format). Despite concern about the role of student motivation, few studies have investigated the relationship between how students approach tests and their levels of achievement in large-scale testing settings (Baumert & Demmrich, 2001), and in consequence little attention has been paid to the possible existence of different *types* of examinee. Yet it seems quite plausible that examinees should display individual variation in terms of the strategies deployed to answer test items, especially in low-stakes scenarios, and that there may therefore be a number of different types of test-taker, and consequently different ways of treating the items encountered. Despite the fact that recent studies have shown motivation toward science to significantly affect achievement-related performance, in PISA 2006, students' science motivation data was not taken into account in the calculation of their scientific literacy scores. Thus, in the current study, we set out to answer the question of "who" omits items in science tests in terms of the motivational dimensions of students' engagement with science.

1.3. 1.2. The present study

As outlined above, the aim of the present study was to advance understanding of students' omitting behaviours in a low-stakes assessment contexts such as PISA. More specifically, our objectives were: a) to evaluate the relations between missing responses and the Italian PISA 2006 science scores; b) to identify the presence of homogeneous subgroups of students displaying different patterns of missing responses;

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