

Science Education

Talent Recruitment and Public Understanding

Edited by

Peter Csermely

Semmelweis University, Budapest, Hungary

and

Leon Lederman

Illinois Mathematics and Science Academy, Aurora, USA



Amsterdam • Berlin • Oxford • Tokyo • Washington, DC

Published in cooperation with NATO Scientific Affairs Division

Proceedings of the NATO Advanced Research Workshop on
Science Education: Talent Recruitment and Public Understanding
19–21 April 2002
Budapest, Hungary

© 2003, IOS Press

All rights reserved. No part of this book may be reproduced, stored in a retrieval system, or transmitted,
in any form or by any means, without prior written permission from the publisher.

ISBN 1 58603 308 5 (IOS Press)
ISBN 4 274 90565 9 C3040 (Ohmsha)
Library of Congress Control Number: 2002115739

Publisher

IOS Press
Nieuwe Hemweg 6B
1013 BG Amsterdam
Netherlands
fax: +31 20 620 3419
e-mail: order@iospress.nl

Distributor in the UK and Ireland

IOS Press/Lavis Marketing
73 Lime Walk
Headington
Oxford OX3 7AD
England
fax: +44 1865 75 0079

Distributor in the USA and Canada

IOS Press, Inc.
5795-G Burke Centre Parkway
Burke, VA 22015
USA
fax: +1 703 323 3668
e-mail: iosbooks@iospress.com

Distributor in Germany, Austria and Switzerland

IOS Press/LSL.de
Gerichtsweg 28
D-04103 Leipzig
Germany
fax: +49 341 995 4255

Distributor in Japan

Ohmsha, Ltd.
3-1 Kanda Nishiki-cho
Chiyoda-ku, Tokyo 101-8460
Japan
fax: +81 3 3233 2426

LEGAL NOTICE

The publisher is not responsible for the use which might be made of the following information.

PRINTED IN THE NETHERLANDS

Talent, Science and Education: How Do We Cope with Uncertainty and Ambiguities?¹

Katya STOYCHEVA

*Institute of Psychology, Bulgarian Academy of Sciences,
Acad. G. Bonchev St., Blok 6, Floor 5, Sofia 1113, Bulgaria*



Abstract. The paradigm of tolerance - intolerance of ambiguity is applied to the analysis of the relations between science education and talent development. First, I examine the role ambiguity tolerance plays in creativity and talent development. Second, I discuss research data and findings on the impact of education on tolerance of ambiguity. Finally, I propose a view on science education that links the promotion of scientific talent with public's understanding of scientific research.

1. Introduction

Uncertainty and ambiguities are implicit to human life. We have only limited control over the natural and social conditions of our life. Neither can we fully control our own behaviour and its effect upon environment, other people and ourselves. Our life is filled with ambiguous situations. These are situations where we have to act with lack of clarity or lack of information, and novel or uncommon situations where our true and tried, learned ways of thinking and acting do not solve the problem. Probabilistic natural events and human interactions with uncertain outcomes are also challenging us. Emotional ambivalence and cognitive incongruity are difficult to deal with. We often have to face fragmented or contradictory information that entails multiple meanings and which we cannot easily structure and understand (21).

Therefore we have to cope with uncertainty. We have to learn to live with ambiguities that are inherent to our life. Both individual and society have developed ways to deal with uncertainty and ambiguity, and both individuals and societies differ in the ways they do it.

¹ The preparation of this paper benefited largely from a NATO Scientific Research Fellowship the author carried out at the Laboratory of Cognition and Development (UMR 8605) at Université René Descartes in Paris, France, in 2001.

Individuals are more or less tolerant of ambiguity, and cultures are characterised by a different degree of uncertainty avoidance.

1.1. Individual's response

How people experience an ambiguous situation and what they do in such a situation is indicative of the degree of tolerance - intolerance of ambiguity they have. Individual differences in ambiguity tolerance manifest themselves in the content and the form of the representations that individuals create in ambiguous situations, in the direction of the actions they undertake, and in the accompanying affect (6,8).

People who are intolerant of ambiguity perceive and interpret ambiguous situations as a source of psychological discomfort or a threat, seem confused by ambiguity and tend to avoid it. When faced with ambiguity, they experience intense negative affects like anxiety and stress. Their reactions are defensive, disorganised and accommodation to the situation is blocked. Intolerant people are likely to arrive at "black-and-white" judgements, to reduce their view of the situation to certain, simple and familiar cues, and defend themselves through rigid, stereotyped behaviours which lead them to less than optimal solutions to the problem.

Conversely, tolerant people are better able to tolerate the feelings of anxiety and uncertainty induced by ambiguity. Their affective reactions are less intense and more varied. They will perceive and interpret an ambiguous situation more adequately, in a realistic way, without denying or distorting parts of its complexity. Tolerant people are likely to elaborate more adaptive and better co-ordinated behaviour. They can withstand the discomfort of the ambiguous situation long enough as to accommodate and generate more appropriate and flexible responses to it.

1.2. Culture's response

From a different perspective, Hofstede (13,14) argues that societies cope with uncertainty in nature through science and technology (the domain of human artefacts). We also rely on low, or formal and informal rules and norms that guide social relations, to defend ourselves against uncertainty in the behaviour of other people. Finally, religion (in the sense of revealed knowledge of the unknown) helps us to accept the limitations of life and our own limitations in this life. Ways of coping with uncertainty belong to the cultural heritage of the society and are transferred and reinforced through socialisation and education. They are reflected in the collectively held values, the life of social groups, the way organisations function, and in the governmental policy.

Science therefore is a powerful tool that human society uses in the face of the unknown and the unpredictable in nature and culture around us and within us. First of all, science provides us with *knowledge* about the nature of the phenomena we have to deal with and the laws that govern their existence across time and space. Second, science is a source of *technologies* that help us to deal with uncertainty and ambiguity. At a third place come *technical objects* that appeared as a result of the practical application of scientific knowledge and technology to the solution of different problems in human life.

On the other hand, **education** is seen as a context for socialisation in tolerance - intolerance of ambiguity. Through education young people acquire knowledge, and this

knowledge impacts their images of the world, of the human being and of life in general. Through education young people gain command of technology and of the skills that are necessary for the use of technical objects. Also at school boys and girls learn those formal and informal rules and norms that help us cope with uncertainty and ambiguity in social interactions. They further adopt a system of values which supports their images of the world, the life, the people and oneself. Education realises its aim through the teaching of knowledge, the practice of skills, the formation of attitudes and by developing students' various abilities and character.

The need to avoid uncertainty is universal, but the strength of this need differs among nations, groups within nations, and individuals (13,14). Cultural differences in uncertainty avoidance may affect, for example, the predominant type of intellectual and scientific activity or schools' organisation. Scholars in high uncertainty avoidance countries would look for certainties, they have stronger theoretical orientation which is related to the need for absolute truth. In low uncertainty avoidance countries scientists would adopt a more empirical and pragmatic approach, looking for usable knowledge. Schools which function within high uncertainty avoiding context are more likely to tend towards standardisation, to have more structuring activities, written rules and ritual behaviour and to promote specialists who value expertise, are task oriented, consistent in their style, and less willing to make individual and risky decisions. Contrarily, schools operating within a low uncertainty avoiding context can be pluriform in structure and functions and would employ specialists who are pragmatic, more interpersonally oriented and flexible in their style, who are involved more in strategy than in details and are more willing to make change and assume risks (13,14).

2. Science Education and Talent Development

Within this paradigm, science education is an instrument for socialisation: young people acquire scientific knowledge, technology and technique through education. This process enables young generations to learn from their culture's experience in the ways of coping with uncertainty and ambiguities in life. Therefore, science education serves the conservation and translation of cultural traditions and human artefacts and the reproduction of scientific knowledge, technology and technique in the society.

However, science education has more than this *conservative, reproductive aspect*. Science, we said, produces knowledge, technology and technique that help people to better control their environment and their own life. Science creates something new, original and useful in the sense that it appropriately responds to human needs and solves problems. Science therefore is a creative activity and for it could successfully perform its social role, it needs creative people to get engaged in this activity. Thus science education has also to do with the identification and the development of the scientific talent in young people. This more *productive, innovative aspect* of science education suggests somewhat different array of educational goals and means.

Science education therefore needs to integrate its conservative and innovative sides. It might not always be easy to find an appropriate balance between reproductive and productive activities within the curricula: they imply the use of different type of tasks and materials, of problem solving approaches and evaluation procedures. Teachers' attitudes, skills and methods play an important role in this process.

This paper explores tolerance of ambiguity at the cross - road of science education and talent development. First, I will point out how tolerance of ambiguity relates to creativity and to the development of the creative talent. Then I will analyse the impact of education on the development of ambiguity tolerance. In conclusion I will propose my point of view on science education that promotes both talent recruitment and public understanding of the scientific research.

Empirical data from Bulgaria come from:

1 A large scale research project² examining the development of ambiguity tolerance in adolescents and young adults (29). In *the first study* a questionnaire for measuring ambiguity tolerance (MAT-50 of Robert Norton, (21)), adapted for use with Bulgarian population, and was administered to 392 high school children, 472 university students, and 116 18 - 25 year old working adolescents. *The second study* contrasted two groups of high-school students, identified as low (n = 51) and high (n = 55) ambiguity tolerant on the basis of their test scores in the first study. They were compared with respect to their intelligence, creative thinking abilities, temperament, anxiety, need for achievement and self-concept. *The third study* involved 303 high school students aged 14 to 19, their teachers (n = 52) and parents (n= 236). An original psychological instrument has been designed to assess the attitudes of adolescents and adults towards different ambiguity tolerant and ambiguity intolerant behaviours. The scale was used to measure the importance adolescents assign to these behaviours and to evaluate adults' encouragement of ambiguity tolerance - intolerance in adolescents (29).

2 A study of 31 boys and 75 girls, aged 14 to 19, who were enrolled in grades 9th to 12th of a high school specialised in applied arts. Subjects filled in questionnaires for measuring ambiguity tolerance, creative motivation and need for achievement (30).

3 A study comparing university students (29 men and 31 women) and non-university youth (25 men and 28 women) with respect to their tolerance of ambiguity, the retrospective evaluation of parents' encouragement of ambiguity tolerant - intolerant behaviours and some demographic indicators of the transition from adolescence to adulthood. This study was carried out by my student Elena Glutnikova for her BA thesis in psychology (10).

4 A study involving 35 men and 87 women aged 18 to 62 investigated the relations between ambiguity tolerance, professional preferences and professional choice in adults. This study was carried out by my student Krassimira Komneva for her BA thesis in psychology (17).

3. Ambiguity Tolerance and Creativity

Creativity is a human activity which results in the production of new, original and appropriate solution to a problem, whether it is an object, a theory or a personal or social act embedded in a particular human interaction. Theories of creativity emphasise the importance of ambiguity tolerance for the creative endeavour. On the other hand,

² This project has been supported by the Johann Jacobs Foundation.

psychological research suggest that *tolerance of ambiguity* as a characteristic of personality self-regulation in ambiguous situations builds upon individual's creative capacities. Thus ambiguity tolerance and creativity are interrelated and mutually enhance themselves.

Below I specify some of the conceptual links between ambiguity tolerance and creativity and provide empirical examples.

3.1. Tolerance of ambiguity as a resource for creativity

Creative work puts high demands on one's ability to tolerate the uncertainty induced throughout the creative process. Creative individuals need to accept the concomitant feelings of anxiety and psychological discomfort and learn to cope with. Ambiguity tolerance is thus a valuable resource for creativity (28). When, for example, the problem is not clearly defined or data does not fit together, tolerance of ambiguity operates in the construction and reconstruction of alternatives and interpretations (28). There could be also external pressures to quickly resolve ambiguities and come up with a ready solution to the problem (1,28). Some of these are contextual pressures, time limitations, others' expectations. External pressures may shorten the time for problem exploration and solution elaboration; they could prevent the individual from trying out as many alternatives as would be needed for the achievement of a truly creative outcome (1,28). Tolerance of ambiguity integrates risk taking, non-conformism, openness for experiences and humour in a dialectical balance between resistance and adaptation that characterise creativity (36).

When faced with incompleteness or unsolved problem, it is important to control the tendency to jump directly to an easy, simple and unambiguous completion of the task. Resistance to premature closure and psychological openness are beneficial to the creative process (28,35). This is recognised, for example, by designers of creative problem-solving methods: they have developed deliberate techniques to defer judgement and keep the problem open, allowing time and space for a free and flexible exploration of the incoming information (35)

Ambiguity tolerance is also important for decision making in creativity (31). Decision making is required at crucial moments in the process of generation, evaluation, selection and implementation of solutions. These are, for example, when to evaluate ideas, how to judge their originality and relevance, whether to persist or leave a stubborn problem, where to look for new possibilities, is the creative product ready to be accepted by the public. Tolerating ambiguity helps to maintain long enough an open-ended approach to the decision making and avoid premature closure on a single option (31).

However, people who are highly tolerant of ambiguity are not necessarily creative achievers. Ambiguity tolerance is just one of the individual resources required for creativity. Intellectual competencies, domain-specific knowledge and skills, creativity-relevant abilities and skills, task commitment, motivation and other personality traits and processes are also important (1,28,35,36). Tolerance for ambiguity is necessary for creativity but is not enough.

Other theorists (for example, Rogers (27), Maslow (19)) link creativity to the process of self - actualisation. In this perspective, openness to experience, lack of rigidity and defensiveness, and tolerance for ambiguities are inner conditions for creativity. The relation between self - actualisation and perceptual-cognitive processes involved in ambiguity

tolerance was also supported in an empirical study with university students (7). In a similar vein, ambiguity tolerance was associated with playfulness in adults, and both related positively to a creative personality type, characterised by spontaneity, openness to experience, intuition and insight (33).

3.2. Ambiguity tolerance and motivation for creativity

An important element of individual's creativity is motivation (1,28,35,36). Motivation regulates the investment of time and efforts in problem solving, puts into action cognitive and personality resources, contributes to the development of domain-relevant creative skills and supports life-long creative performance.

My research allows to specify *the motivational role of ambiguity tolerance in creativity*. It has been found that 1) creative motivation and need for achievement are positively correlated; 2) ambiguity tolerance correlates positively with creative motivation, and 3) ambiguity tolerance doesn't correlate with need for achievement (30). Tolerance of ambiguity may empower the intrinsically motivated exploration of novel, unusual or complex stimuli and situations. In this way ambiguity tolerance contributes to the creative process. However, ambiguity tolerance is not related to the search for high standards of achievement in the results of the creative work. This conclusion is further supported by the fact that two groups - of high and low ambiguity tolerant adolescents, didn't differ in their need for achievement (29).

On the other hand, the observed positive correlation between ambiguity tolerance and creative motivation suggest that creative motivation may contribute to adolescents' tolerance of ambiguity (30). Similar pattern of relations was observed among 5-graders (20): subjects classified in the high-curiosity group were also more tolerant of ambiguity than those in the low-curiosity group. An individual who has developed creative attitudes and interests is likely to invest more time and effort in the exploration of novel, unusual or complex stimuli. In this way one may be able to avoid stereotypical perception and premature reaction to the ambiguous situation.

3.3. Shared abilities and skills

We have found that ambiguity tolerant adolescents outperformed those who were intolerant of ambiguity on both verbal and non-verbal creativity tests (29). Ambiguity tolerant students were able to generate more original and unusual ideas and solutions to open-ended verbal tasks. They also provided more inventive, imaginative and abstract titles to their pictures - titles that go beyond what can be seen. The positive association between ambiguity tolerance and creative thinking was confirmed in other studies too (15,34).

Complex relations between creativity and ambiguity tolerance emerged in a research on multicultural education (9,22). A cross-cultural simulation game was found to increase ambiguity tolerance among undergraduate students. The authors further demonstrated that creative ability and gender produce differential effect of the cross-cultural simulation game on subjects' personality (22): high creative subjects exhibited a greater shift in tolerance of ambiguity than low creative ones, in particular high creative females who scored highest in ambiguity tolerance at the post test measurement. These findings suggest that creative abilities and skills make it easier for an individual to be and to become tolerant of ambiguity.

In sum, what makes you creative in parts makes you also tolerant of ambiguity. Abilities that are relevant to creativity appear also to contribute to one's tolerance of ambiguity. These are, for example, flexibility, originality, capacity for abstraction, cognitive complexity, and curiosity. Conversely, characteristics which aim at protecting someone from encounters with ambiguity will also hinder his/her creative performance. This may happen in different ways. First, by limiting the possibility that one's curiosity, interests and motivation for creativity will be challenged. Second, by limiting one's possibilities to acquire creativity-relevant skills and knowledge. Third, by the choice of traditional paths, value conformity and rule-abiding. Intolerance of ambiguity will draw the individual towards familiarity and away from discovering. It will prevent him/her from facing the unknown and the unusual and gaining positive experience in dealing with it. Unwillingness to take risks and conservatism will limit the range of explored alternatives and of one's self-confidence (1,8,16,28,35,36).

3.4. Ambiguity tolerance and creative vocation

We have found that tolerance of ambiguity in adults is related to a preference for occupations which are characterised by high degree of ambiguity and high degree of freedom (17). In a study involving Canadian high school girls, intolerance of ambiguity at grade 12 was related to the traditionalism of the desired vocation 3 years later (26). Since the above characteristics apply to most of the creative professions, ambiguity tolerant people are more likely than intolerant ones to be inclined towards creative fields of work. Also, ambiguity tolerance seems relate to a cluster of traits and abilities that are desirable in creative professions. Some of these are openness to new ideas, exploratory orientation, cognitive complexity, capacity for abstraction, and imagination (8,16).

On the other hand, exercising a creative profession may develop one's abilities to cope with ambiguity. This suggestion is supported by a study which examined a sample of college educated women with middle-range creativity in a life-span perspective (12). Both creative potential (assessed at age 21) and creative achievement (measured at age 52) were positively associated with an increase in tolerance of ambiguity during this period. It was also found that achievement of identity (through commitment to creative work) interacted with creative potential in the prediction of creative achievement (12).

4. Education and ambiguity tolerance

We have mentioned earlier that knowledge, skills and attitudes which help people to cope with uncertainty in life have been preserved in the cultural heritage of the humanity. We also said that individuals acquire those knowledge, skills and attitudes through education. We may infer therefore that *education and formal training one has received* are important for the development of his/her ambiguity tolerance. Empirical data confirm this expectation: university students have higher tolerance of ambiguity than their age mates who are not enrolled in a university (10,29). Similarly, in adults higher educational level is associated with higher ambiguity tolerance across the life span (17). Studies with university students however showed no clear relation between university attendance and increase in tolerance of ambiguity (see, for example, (18)). From the study of creativity we also know that knowledge can inhibit the ability to deal effectively with novel and complex tasks, i.e. with ambiguous situations. This may happen, for example, when one gets rigidly stuck

within traditional approaches and paradigms. Obviously, the relationship between ambiguity tolerance and one's education is not a direct one, and more research is needed in order to understand how the amount of education relates to tolerance of ambiguity.

Findings suggest that ambiguity tolerance relates to *the type of education* as well: students in arts outscore those from the business (32) and in the medical and technical universities (29). Do high ambiguity tolerant students prefer this field of study or the educational setting channels students' personality in that particular way? There is evidence that students in medicine who are tolerant of ambiguity tend to choose relatively unstructured specialities while those who are intolerant of ambiguity tend to select relatively structured fields (3). A speciality in which it is relatively easy to make diagnoses, prescribe therapies, evaluate the progress and the relations with the patients are relatively clear-cut are considered to be relatively structured. Psychiatry emerged as least structured, while obstetrics - gynaecology and surgery were among the most structured (3). Respectively, tolerance for ambiguity was found to be positively associated with preference for psychiatric career and interest in psychological factors in illness (37), but controversial findings were reported as well (5).

On the other hand, the personalised and flexible learning process, using ambiguity as a creative challenge, seems favouring ambiguity tolerance more than the group adherence to structured anonymous knowledge: the difference between the students in arts and the students in medicine is small and statistically negligible in the first year (less than 7 points) and significant at the end of their higher education cycle (more than 16 points) (29). These findings indicate that not only the fact of *being educated* bears upon ambiguity tolerance. *What you are educated in* and *the way you are educated* seem also important for the development of ambiguity tolerance.

4.1. Is tolerance of ambiguity valued at school?

One of the most powerful ways in which a culture encourages or discourages certain behaviour is the way by which teachers (and parents also) reward or punish certain personality characteristics as they develop in children and the behaviours which manifest those characteristics.

Table 1 visualises the results we have obtained in a study of ambiguity tolerance among Bulgarian high school students and their teachers (29). More than 90% of all teachers having classes with the examined students were involved, so there were science teachers in the sample too. Teachers' age ranged from 24 to 55, they had from 1 to 32 years of teaching experience in school and 25% of them were men.

The scale we used consisted of 7 behaviours that are indicative of ambiguity tolerance (AT) and 7 ambiguity intolerant (AInT) behaviours. Teachers were asked to indicate how often they encourage these behaviours in their pupils on a 4-point rating scale. Students were asked to indicate, on a 4-point rating scale, 1) how important these behaviours are for themselves, and 2) how often their teachers encourage these behaviours in them? Answers were coded in a way that greater encouragement or importance was indicated by a lower score (29).

Table 1. Means and standard deviations for teachers' self-reported encouragement of AT - AInT behaviours in students, students' perception of teachers' encouragement for AT - AInT behaviours in students, and students' evaluation of the importance of AT - AInT behaviours for themselves

Characteristics		Teachers	Teachers by students	Students
1. Puts to test him(her)self by experimenting in different situations.	AT	1.73 (0.63)	2.57 (1.04)	1.79 (0.88)
2. Prefers well established aesthetic values.	AInT	1.64 (0.69)	1.94 (0.84)	2.50 (0.93)
3. Holds definite opinion and judgements about most things.	AInT	2.08 (0.84)	1.77 (0.87)	1.79 (0.85)
4. Enjoys unexpected situations and surprises.	AT	1.96 (0.77)	2.96 (0.93)	1.89 (0.93)
5. Chooses situations with clear chances for success.	AInT	2.31 (0.97)	1.79 (0.92)	1.75 (0.88)
6. Prefers situations with no strict rules and no prescribed ways of doing things.	AT	2.19 (0.91)	2.82 (0.96)	2.17 (0.99)
7. Apt to non-traditional profession.	AT	1.96 (0.74)	2.85 (0.92)	2.53 (1.05)
8. Avoids risks.	AInT	2.63 (0.77)	2.05 (1.02)	2.47 (1.10)
9. Puts to test his (her) abilities with complex tasks which he (she) might not succeed to solve.	AT	1.75 (0.81)	1.98 (0.98)	2.10 (1.06)
10. Strictly follows the norms and the rules set at home and at school.	AInT	1.77 (0.70)	1.52 (0.87)	2.61 (0.94)
11. Prefers to be on the safe side.	AInT	2.19 (0.86)	1.65 (0.75)	1.97 (0.95)
12. Willing to participate in new endeavours and to take risk.	AT	1.75 (0.68)	2.59 (0.95)	1.99 (0.92)
13. Prefers the well known certain things.	AInT	2.60 (0.72)	1.77 (0.82)	2.29 (0.95)
14. He (she) is rather original and non-traditional in his (her) tastes and preferences.	AT	1.67 (0.76)	2.87 (1.01)	1.98 (0.95)

The development of ambiguity tolerance as a personality disposition goes in line with the adoption of appropriate values and beliefs. Bulgarian adolescents assign more importance to ambiguity tolerant ($M = 14.44$, $SD = 3.75$) than to ambiguity intolerant behaviours ($M = 15.42$, $SD = 3.88$) - $t = 2.73$, $p < 0.01$. While they value tolerance of ambiguity more than intolerance, certainty seeking behaviour is appreciated as well. Although preferring situations with clear chances for success, they accept to test themselves by taking risks, experimenting in different situations and participating in new endeavours. Unexpected situations and surprises are enjoyable, but it is also important to be on the safe side and to build up a definite opinion about things in life.

So do teachers: they reported encouraging ambiguity tolerance ($M = 13.12$, $SD = 2.97$) more than ambiguity intolerance ($M = 15.16$, $SD = 3.48$) - $t = 2.76$, $p < 0.01$. Teachers' self - reported degree of AT encouragement was the highest one we have observed in this study. There were no significant differences in the degree of encouragement of AT - AInT behaviours related to teachers' age and teaching experience. Male and female teachers were equally supportive to AInT behaviours but women encouraged stronger AT behaviours in their students ($t = 2.45$, $p < 0.05$), in particular their non - traditional aesthetic preferences ($t = 3.94$, $p < 0.001$) and occupational choices ($t = 2.00$, $p = 0.05$).

What is students' perception of teachers' evaluative behaviour? Adolescents think that intolerance of ambiguity ($M = 12.49$, $SD = 3.43$) is much more important than tolerance ($M = 18.74$, $SD = 3.80$) for their teachers - $t = 18.93$, $p < 0.001$. Students also see their teachers as valuing tolerance of ambiguity less ($t = 13.82$, $p < 0.001$) and intolerance of ambiguity more ($t = 9.76$, $p < 0.001$) than they do themselves. Therefore, there is a strong discrepancy between teachers' self-reported encouragement for ambiguity tolerant - intolerant behaviours and the way their reward strategies are perceived by students.

Though teachers keep on the traditional, well known practice, they see themselves as rather open to new and unusual ways of doing among their students. Their professional status may have contributed to their understanding of what promotes adolescent development in school and his/her successful after-school adaptation to work and social life. However, this seems being unnoticed on the other side: adolescents think teachers want them to avoid risks and uncertain outcomes.

Works on attitude - behaviour consistency teach us that generalised self-reported attitudes do not necessarily match one's behaviour in a particular situation. It seems understandable then that teachers' declared attitudes may differ from the way students perceive the actual behaviour of the teacher in the classroom.

Or, may be teachers are unable to identify ambiguity tolerance as it manifests itself in adolescent behaviour? If so, they wouldn't be able to offer the support they believe should be given to students. This point hadn't been examined in our study. However, research in other age groups and educational contexts suggest that teachers' evaluations could be a reliable measurement of one's ambiguity tolerance. For example, a teacher-generated index of intolerance of ambiguity obtained at age 3,5 was found to be correlated with child's personality and behavioural manifestations at ages 4,5 and 7 (11). Also, faculty members were able to evaluate students on characteristics associated with ambiguity tolerance (e.g. need for structure, openness to new ideas) six months after students' enrolment in the college. The obtained correlation of faculty evaluations and students' scores on an ambiguity tolerance scale ($r = 0.45$, $p < 0.01$) suggests that faculty were sensitive to this dimension (32).

The value adolescents assign to ambiguity tolerance - intolerance is somewhat related to their teachers' evaluative standards. This was indicated by the significant though small positive coefficients of correlation we obtained (range 0.13 - 0.41). Students who value ambiguity tolerance higher think their teachers emphasise risk avoiding and certainty seeking to a greater extent. On the other hand, students who rate intolerance of ambiguity as less important tend also to see their teachers as less supportive for ambiguity tolerant behaviours. What might be the underlying psychological mechanisms ?

It seems like students adopt values in opposition to what they perceive to be the expectations of their teachers. It could be that adult authority is seen as a source of evaluative pressure. Then this generalised adolescent perception may have an impact on their values. The observed discrepancy in the perception of teachers' reward strategies seems being part of adolescents' "subjective reality". In this sense teachers' "restrictive conservatism" serves the adolescent need for autonomy, emancipation from adults and self-determination.

In support to this suggestion was found that students' ambiguity tolerance has a significant effect on their perception of teachers' encouragement for AT ($F = 6.40$, $df = 1$, $p < 0.05$) and AInT behaviours ($F = 4.12$, $df = 1$, $p < 0.05$) - students with higher ambiguity tolerance perceived their teachers as encouraging less both AT and AInT values. It appears that more ambiguity tolerant beliefs were developed in relation with a perception of the teachers as having less evaluative power over one's own behavioural standards. Similarly, a study with Canadian adolescents has found significant negative correlation between students' scores of ambiguity tolerance and their needs for structure, i.e. the need to be offered guidance, advice, information, clarity or direction by an adult figure of authority (4). Also, ambiguity tolerance was found to significantly relate to the process of identity formation (25).

5. Conclusion: From Understanding through Acceptance to Support

Nowadays high school students will all contribute to the future of the science, either as actors or as a public. For scientists and public are both important for the development of scientific research. Scientists will confront the unknown and will apply their knowledge, skills and personality to define problems, generate ideas, test hypotheses, select criteria and elaborate solutions. Then they will work for the implementation and the acceptance of the scientific results.

On the other hand, social judgement is needed to acknowledge the creativity of the scientific results. The initial decision about what is creative and what is not is made by the creator. However, product's originality, relevance and mastery are finally judged by the targeted audience. It is a social consensual judgement that recognises the creative solution to the problem (31).

The public will provide support for the scientific research depending on the way science is perceived and understood. Society's images of science and scientists influence the very existence of this domain, its relations with the wider social system as well as the recruitment of its members, the recognition of its achievements and the application of its results (2,23,24). Nowadays negative traits can be discerned in the traditional highly positive image of the scientist. The scientist has more social roles than before, and it is not always easy to match the expectations for scientist, manager, administrator, and politician at one and the same time. The expansion of "big science" and of scientific technologies, the increased dependence of scientific investigations on substantial external funding, the invasion of mass media in the scientific work, and the general social development all contribute to the emergence of a dramatised, controversial representation of the science, where criticising and advocating, promise and concern, risks and benefits, support and resistance strive for balance (23,24).

How can scientists and public integrate contradictions and change into a new "working" model of the science? In the present situation, what attitudes should we promote, both among scientists and public, so that a space could be open for both scientific research and its acknowledgement?

Let me conclude on this note. If tolerance of ambiguity is a valuable resource for science and scientists, then science education in school should serve a double purpose. First, to select students with high tolerance of ambiguity for science and support the

development of their creativity. Second, to promote tolerance of ambiguity and creativity in students' understanding of science and scientific research.

References

- [1] T. Amabile, Within You, Without You: The Social Psychology of Creativity, and Beyond. In: M. Runco and R. Albert (eds.), *Theories of Creativity*. Sage, Newbury Park, CA, 1990, pp. 61-91.
- [2] P. Bojadjieva *et al.*, *Science - Life Outside the Laboratory*. Bulgarian Academy of Sciences Press, Sofia, 1994.
- [3] S. Budner, Intolerance of Ambiguity as a Personality Variable, *Journal of Personality* **30** (1962) 29- 50.
- [4] D. Chabassol and D. Thomas, Needs for Structure, Tolerance of Ambiguity and Dogmatism in Adolescents, *Psychological Reports* **37** (1975) 507-510.
- [5] B. DeForge and J. Sobal, Intolerance of Ambiguity in Students Entering Medical School, *Social Science and Medicine* **28** (1989) 869 - 874.
- [6] E. Frenkel-Brunswick, Intolerance of Ambiguity as an Emotional and Perceptual Personality Variable, *Journal of Personality* **18** (1949) 108-143.
- [7] P. Foxman, Tolerance for Ambiguity and Self-Actualisation, *Journal of Personality Assessment* **40** (1976) 67-72.
- [8] A. Furnham and T. Ribchester, Tolerance of Ambiguity: A Review of the Concept, Its Measurement and Applications, *Current Psychology: Developmental, Learning, Personality, Social* **14** (1995) 179-199.
- [9] J. Glover *et al.*, Effects of a Simulation Game upon Tolerance for Ambiguity, Dogmatism, and Risk Taking, *Journal of Social Psychology* **105** (1978) 291-296.
- [10] E. Glutnikova, Tolerance of Ambiguity in Young Adulthood (18 - 25 Years), Unpublished BA Thesis in Psychology, New Bulgarian University, Sofia, 2000 (in Bulgarian).
- [11] D. Harrington *et al.*, Intolerance of Ambiguity in Preschool Children: Psychometric Considerations, Behavioral Manifestations, and Parental Correlates, *Developmental Psychology* **14** (1978) 242-256.
- [12] R. Helson and J. Pals, Creative Potential, Creative Achievement and Personal Growth, *Journal of Personality* **68** (2000) 1-27.
- [13] G. Hofstede, *Cultures' Consequences*, Sage, CA, 1980.
- [14] G. Hofstede, *Cultures and Organizations: Software of the Mind* (Bulgarian translation Teodora Mihajlowa). Klasika and Stil, Sofia, 2001.
- [15] J. Houtz *et al.*, Problem Solving and Personality Characteristics Related to Differing Levels of Intelligence and Ideational Fluency, *Contemporary Educational Psychology* **5** (1980) 118-123.
- [16] D. Jonassen and B. Grabowski, *Handbook of Individual Differences, Learning and Instruction*. Erlbaum, Hillsdale, NJ, 1993.
- [17] K. Komneva, Tolerance of Ambiguity, Professional Preferences and Professional Choice, Unpublished BA Thesis in Psychology, New Bulgarian University, Sofia, 1999 (in Bulgarian).
- [18] G. Kuh, Persistence of the Impact of College on Attitudes and Values, *Journal of College Student Personnel* **17** (1976) 116-122.
- [19] A. Maslow, *The Farther Reaches of Human Nature*. Penguin Book, London, 1971.
- [20] W. Maw and A. Magoon, The Curiosity Dimension of Fifth-Grade Children: A Factorial Discriminant Analysis, *Child Development* **42** (1971) 2023-2031.
- [21] R. Norton, Measurement of Ambiguity Tolerance, *Journal of Personality Assessment* **39** (1975) 607-619.
- [22] C. Petersen *et al.*, The Effects of a Cross - Cultural Simulation Game on Participants' Personal Characteristics, *Social Behavior and Personality* **6** (1978) 21-26.
- [23] K. Petkova and P. Bojadjieva, The Image of the Scientist and Its Functions, *Public Understanding of Science* **3** (1994) 215-224.
- [24] K. Petkova *et al.*, The Mass Media Image of Science Across the "Iron Curtain": Comparing Britain and

- Bulgaria 1946 - 1994, *Social Studies of Science* (accepted for publication).
- [25] D. Raphael. Identity Status in High School Females, *Adolescence* **13** (1978) 627-41.
- [26] D. Raphael and M. Chasen, Intolerance of Ambiguity and Life Status During Early Adulthood: A Three Year Follow-Up, *Psychological Reports* **47** (1980) 388-390.
- [27] C. Rogers, Toward a Theory of Creativity. In: P. Vernon (ed.), *Creativity*. Penguin Books, Harmondsworth, 1982, pp. 137-151.
- [28] R. Sternberg and T. Lubart, *Defying the Crowd: Cultivating Creativity In a Culture of Conformity*. Free Press, New York, 1995.
- [29] K. Stoycheva, Ambiguity Tolerance: Adolescents' Responses to Uncertainty in Life. Research Report (ERIC Document Reproduction Service No. ED 422 547), 1998.
- [30] K. Stoycheva, Ambiguity Tolerance in Adolescents: Its Relations to Creativity-Relevant Traits, 7th *Biennial Conference of the European Association for Research on Adolescence*, Jena, Germany, 2000.
- [31] K. Stoycheva and T. Lubart, The Nature of Creative Decision Making. In: C. Allwood and M. Selart (eds.), *Decision Making: Social and Creative Dimensions*. Kluwer Academic Publishers, Dordrecht, 2001, pp. 15-33.
- [32] M. Tatzel, Tolerance for Ambiguity in Adult College Students, *Psychological Reports* **47** (1980) 377-378.
- [33] D. Tegano, Relationship of Tolerance of Ambiguity and Playfulness to Creativity. *Psychological Reports* **66** (1990) 1047 - 1056.
- [34] T. Tetenbaum and J. Houtz, The Role of Affective Traits in the Creative and Problem-Solving Performance of Gifted Urban Children, *Psychology in the Schools* **15** (1978) 27-32.
- [35] P. Torrance and T. Safter, *Making the Creative Leap Beyond ...*. Creative Education Foundation Press, Buffalo, NY, 1999.
- [36] K. Urban, Recent Trends in Creativity Research and Theory in Western Europe, *European Journal for High Ability* **1** (1990) 99-113.
- [37] H. Walton, Personality Correlates of a Career Interest in Psychiatry, *British Journal of Psychiatry* **115** (1969) 211-219.