What Makes High-School Girls Think They are Talented (or not Talented) at Maths?

A Qualitative Examination of Intra- and Extra-Personal Influences and Performance Bases

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Reasons for students' self-perceptions of mathematical talent form the basis for this predominantly qualitative study. Participants (N=60) were selected from a larger cohort of 459 Year 9 students from three coeducational government schools in an upper-middle class area of metropolitan Sydney, of comparable socioeconomic status. Interviewees were selected from the large-scale extensive study according to their perceived mathematical talent self-ratings, and their measured mathematical performance on standardised tests. Interview questions focused on the self, significant others, and wider sociocultural influences. Focal groups were girls of high mathematical performance with high self-perceptions of talent, boys of low performance and high talent perceptions, and girls of high performance and low talent perceptions. These groups were of interest in order to explore factors facilitative of high-achieving girls' corresponding high talent perceptions, factors contributing to boys' inflated talent perceptions, and most importantly, factors that act as deterrents to high-achieving girls having high talent perceptions. Cross-sex parallel comparison groups were included in each cell in order to enable identification of gender-specific processes, resulting in a total of six groups, each comprising ten interviewees. Content analysis identified emergent themes for each gender, level of talent perceptions, level of performance, and interactions among these.

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There are many reported findings of gender differences in students' self-perceptions of mathematical ability (eg: Eccles, Jacobs, & Harold, 1990; Jacobs & Eccles, 1992) which are believed to impact on future maths participation in high-school course selection (Eccles, 1984; 1987; 1989; Watt & Bornholt, 1994) and hence maths-related careers (Watt & Bornholt, 1994). Recent Australian research focusing specifically on perception of mathematical talent has also found this to be highly predictive of plans for participation in high levels of maths (Watt & Bornholt, 1994). Perceived maths talent is therefore an important variable for researchers to be concerned with, since it impacts strongly on participation in maths, gender-differentiated patterns in which have long been well-recognised social phenomena.

The present predominantly qualitative study was particularly concerned not simply with confirming well-established findings of boys having higher perceptions of maths talent than girls (eg: Watt & Bornholt, 1994), but rather with examining reasons for girls underestimating their maths talent. Related to this question, was a secondary focus on girls having high achievement and commensurate talent perceptions, to explore factors facilitative of such healthy perceptions, and identify differences between the two groups.

METHOD

Design

Interviews were conducted with six groups of students identified on the basis of their measured mathematical performance and perceived talent self-ratings. Focal groups were girls of high mathematical performance with high self-perceptions of talent, boys of low performance and high talent perceptions, and girls of high performance and low talent perceptions. These groups were of interest in order to explore factors facilitative of high-achieving girls' corresponding high talent perceptions, factors contributing to boys' inflated talent perceptions, and most importantly, factors that act as deterrents to high-achieving girls having high talent perceptions. Cross-sex parallel comparison groups were included in each cell in order to enable identification of gender-specific processes.

Participants

Participants (N=60) were selected from a larger cohort of 459 Year 9 students from three coeducational government schools in an upper-middle class area of metropolitan Sydney, of comparable socioeconomic status (based on socioeconomic index for areas, Australian Bureau of Statistics, 1995). Interviewees were selected from the large-scale extensive study according to their perceived mathematical talent self-ratings, and their measured mathematical performance on standardised tests. The composition of the six groups is illustrated diagrammatically in Table 1.

Table 1

Interviewee Group Composition

	high talent perceptions	low talent perceptions
high maths	10 boys (group 1)	10 boys (group 5)
performance	10 girls (group 2)	10 girls (group 6)
low maths	10 boys (group 3)	
performance	10 girls (group 4)	

Materials

Mathematics Achievement. Students' current performance in mathematics was measured on a standardised Progressive Achievement Test (Form 2B, ACER, 1984). Alternate items (i=28) were selected so that the test could be administered in 20 minutes. Internal consistency for the test as a whole was Cronbach alpha .80, indicating satisfactory reliability for the mathematics test.

Perceptions of Talent. Students' talent perceptions were initially measured by 14 Likert-type items as part of a larger survey. Eight of these were comparative maths talent judgements (eg: Compared with your friends, how talented do you consider yourself to be at maths?), one was a general maths talent rating (How talented do you think you are at maths?) and five were domain-specific talent judgements (eg: How talented do you think you are at geometry in maths?).

Interview Protocol. Interview protocols were identical within paired groups 1 and 2 (high performance, high talent perception), groups 3 and 4 (low performance, high talent perception), and groups 5 and 6 (high performance, low talent perception), but differed slightly across these three pairs. Sections of the protocol relevant to this paper were the first four questions. The first question was open-ended:

> From your responses in the maths survey at the beginning of the year, we can see you feel talented (or not talented for groups 5 and 6) at maths. What we're interested in knowing are the reasons *why* you feel talented (or not talented for groups 5 and 6) at maths?

The second question asked whether students had *always* felt talented at maths (or not talented for groups 5 and 6). If they answered yes, they were asked why. If they answered no, they were asked what had changed their opinion, and when this change had occurred. Third, interviewees were asked whether *most people* thought they were talented (or not

talented for groups 5 and 6) at maths, with follow-up probes specifically targeting family, friends and teachers if these were not mentioned initially. The fourth question asked whose opinions, out of the people they had just discussed, affected what they personally thought, again with follow-up probes about the impact of family, friends and teachers on students' own perceptions if any of these groups were not addressed.

Procedure

The extensive survey from which interviewees were selected was carried out with 459 Year 9 students at the beginning of the school year, with informed consent of the School Principal and parents. Students completed surveys asking about a range of attitudes related to maths and English at high-school. They then completed standardised maths and English tests after the survey, so that their short-term reaction to the test would not affect their answers on the survey. Maths and English tasks were completed on separate days so as not to overburden respondents, and each took place within a regular school lesson with the researcher and regular class teachers present.

The interviews were conducted mid-year following first semester exams, but before students had received their mid-year examination results, in order that reaction to recent results not skew their interview responses. Information and consent forms were sent to parents of targeted interviewees two weeks before scheduled interview dates, resulting in 100% returning consent. There were two interviewers involved, myself and an employed male research assistant. The male interviewer interviewed all the boys and I interviewed all the girls. This decision was made in order to control for the gender interface during interviews, particularly in view of the nature of the interview questions related to sex-typing of maths, which boys might not have felt free to be honest about to a female interviewer, for example.

Individual interviews were conducted with a duration of 20 minutes each. Interviewees were first assured of the confidentiality of their responses and invited to select an alias name for interview and transcription purposes. They were told that the purpose of the interview was to find out in greater depth about their attitudes expressed in the maths survey earlier in the year, and asked if they would permit the interview to be taped. It was explained that the purpose of the taping was because their responses were very important, and because we wanted to transcribe the interview both for analysis purposes, and also as a validity check so that they could comment on and change sections of the transcript if necessary. This last also doubled as an ethical safeguard, in case students revealed something deeply personal that they might later want to retract, for example. All interviewees agreed to the taping of interviews.

After the interview, interviewees were fully debriefed as to the reason for their selection, with the exception of groups having low maths performance and high talent perceptions (groups 3 and 4). It was considered unethical to disclose this apparent mismatch to participants in these groups. Members of these two groups were simply told that they had been selected because of their high maths talent perceptions, and that we were interested in finding out about reasons apart from performance that resulted in students having positive self-perceptions.

Analyses

Exploratory factor analyses, multidimensional scaling, multiple classification analyses and confirmatory factor analyses were employed in deciding the nature and composition of the talent construct, while Cronbach's alpha measured the internal consistency of the performance measure. Content analysis identified emergent themes from the interview data for each prespecified group, and identified patterns across groups with respect to gender, level of maths performance and interactions among these. This allowed identification of processes specific to each group.

RESULTS

Results are presented in six main sections. The first describes the formation of the talent construct, the second describes the interviewee selection procedure, and the following four sections present interviewee responses to the four focal interview questions for each of the prespecified interviewee groups.

Forming the Talent Construct

It was expected that the items measuring perceptions of talent, with the exception of the general maths talent rating, would form two distinct factors, the first comprising comparative talent judgements, and the second domain-specific talent judgements. Exploratory factor analysis specifying a two-factor solution showed, however, that two of the comparative items loaded on the domain-specific factor, and two other items were smeared across both factors. Consequently, a second factor analysis was performed, using the residuals after regressing all comparative and domain-specific items on the general talent rating. The resulting factor structure was almost identical to that above, indicating there was no 'masking' effect of general maths talent perceptions obfuscating the differentiation of comparative and domain-specific talent judgements. A confirmatory factor analysis using LISREL, again specifying the hypothesised two-factor structure, also yielded unsatisfactory model fit ($c_{(64)}$=380.18 $p<.001$, GFI=.885, AGFI=.837, RMSR=.04).

A multidimensional scaling was then performed to obtain a visual depiction of the relationships between the items in the two-factor space (stress=.157, RSQ=.923). This revealed that two of the comparative (class and level) and two of the domain-specific items (algebra and statistics) exhibited unexpected behaviour (see Figure 1). These four items were discarded for the purposes of a third factor analysis, again specifying a two-factor solution, which still did not yield a clear factor structure. Consequently it was decided a one factor solution was most appropriate.

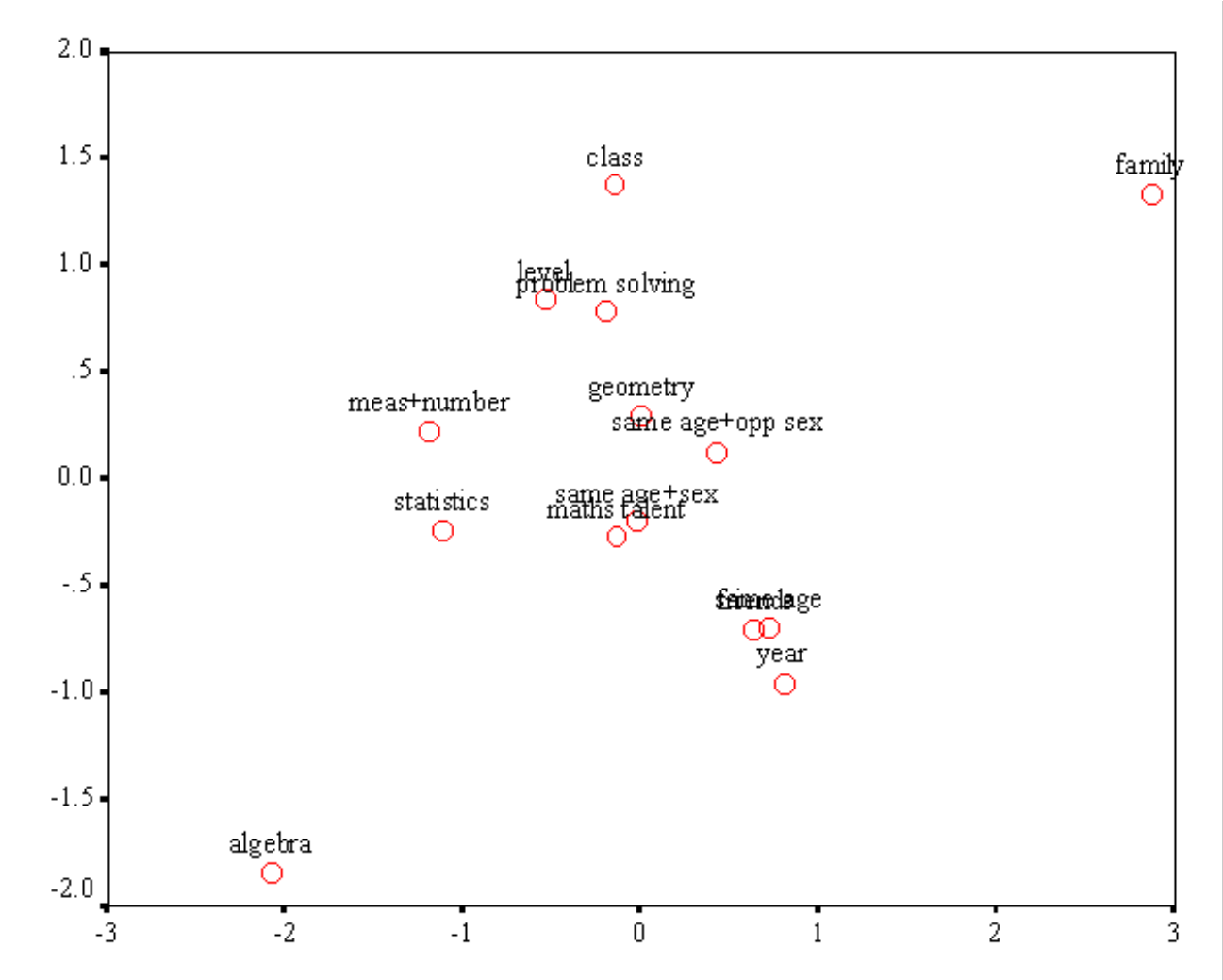

Figure 1. Derived stimulus configuration for items measuring maths talent.

Since this was a one-factor solution, it was decided to select only those items that best measured the construct. Using the general maths talent rating as the criterion variable, multiple classification analyses were conducted to see which of the 13 other items best predicted correct group membership on the criterion variable. The 7-point Likert-type scale measuring general maths talent perceptions was split into three groups, the first signifying low (ratings < 4), the second high (ratings > 4), and the third mid-levels (ratings = 4) of general maths talent. In the first analysis, items were used to predict membership of the first two criterion groups. Use of the comparative talent items yielded 85.57% correct classification, while domain-specific talent items yielded 89.93%, and all items combined yielded 90.94%. Examination of the item correlations with the discriminant function in each of these three cases showed those which were consistently the highest were three of the comparative items (comparisons with school Year, friends, and students of the same age and sex) and three of the domain-specific items (domains of geometry, measurement and number, and statistics). A stepwise procedure supported the selection of these six items, through examination of residual variance after entering each item.

A second multiple classification analysis predicting correct group membership of all three of the low, mid and high levels of general maths talent ratings, showed comparative talent items yielded 77.34% correct classification, while domain-specific items yielded 76.47%. The same six items as in the two-group classification above had the strongest correlations with the discriminant function in each case.

Although comparison with students of the same age and opposite sex was not identified as one of the items best measuring the talent construct, it was decided to include this for theoretical reasons, since the item comparing students with others of the same age and same sex had been selected. A final multiple classification analysis was run to assess the extent to which these seven items predicted correct group membership on the general talent scale. In predicting membership of the low and high general talent ratings 88.93% accuracy was obtained with the seven discriminating variables. For the low, mid and high criterion groups there was 76.53% correct classification. Since these proportions were similar to those obtained from using all 13 items, it was decided these seven selected items were those that best measured perceived mathematical talent, along with the general maths talent self-rating.

A one-factor congeneric model was computed using LISREL, to obtain factor loadings for each of the eight items, and measure construct validity. The model fit was substantially improved from the initial two-factor model ($c_{(16)}$=90.79 $p<.001$, GFI=.950, AGFI=.888, RMSR=.027), indicating that one talent construct comprised of the selected eight items was appropriate. Summary statistics for the derived talent construct were M=4.53 SD=1.08 overall, M=4.79 SD=1.09 for boys and M=4.29 SD=1.10 for girls. Distributions were symmetric in each case (skewness= -.30 overall, -.43 for boys and -.44 for girls).

Selecting the Interview Groups

Initially it was decided to use the 25th and 75th percentiles for boys and girls as cut-offs on each of the perceived talent and maths performance measures to indicate low and high scores on each. On this basis, the total numbers of students in each of the prespecified interview groups (see Table 1) were 33, 0, 9, 4, 7, 44, respectively for groups 1 to 6. In other words, there were no girls meeting the criteria of high maths performance and high perceived maths talent, few girls (n=4) with low performance and high talent perceptions, with most girls (n=44) having high performance and low talent perceptions. While this was particularly interesting in and of itself, the selection procedure yielded insufficient numbers of students to interview within each cell. It was decided to use the top and bottom thirds as cut-offs, yielding 47, 38, 15, 10, 15, 14 students respectively for each of the prespecified interview groups. It was decided to use the minimum cell size (n=10) as the number of students to select from within each cell. Interviewees were then randomly selected from within each of the remaining five cells.

Responses to the Initial Open-Ended Question about why Students Felt Talented or Not

Students were allowed multiple responses to the initial open-ended question asking why they felt talented (or untalented for groups 5 and 6) at maths, with most students giving two reasons. Among high-achieving students with commensurate talent perceptions, reasons as to why they felt talented at maths in response to the initial open-ended question differed for boys and girls (groups 1 and 2 respectively, see Table 2). For boys, the most common

response was that they got high marks (n=8), and secondly that they did not find it hard (n=6). A couple of boys mentioned being in a high stream as contributing to their perceptions of talent, with one boy stating he tried hard and another that he received positive feedback. For girls, similar numbers mentioned high marks (n=4), being in a high stream (n=3) and the fact that their parents were good at maths (n=3), with a couple also saying they did not find it difficult and tried hard. One girl also stated enjoyment as a reason for her feeling talented.

There were also differences between boys' and girls' responses regarding reasons for feeling talented among students with high talent perceptions and low measured mathematical achievement (groups 3 and 4 respectively, see Table 2). Most boys cited maths not being hard as the major reason for feeling talented (n=6), with others citing high marks (n=4), trying hard (n=3), enjoyment (n=1) and confidence (n=1) as contributing to their self-perceptions of talent. For girls, the most common response was also not finding maths hard (n=7), with high marks also being the second most common reason (n=5), with other factors being positive feedback (n=4), their parents being good at maths, enjoyment, position within their class, confidence and maths being the subject at which they performed best (n=1 in each case).

Table 2

Responses to Open-Ended Question about why Students Felt Talented at Maths (groups 1-4)

	boys - G1	girls - G2	boys - G3	girls - G4
high marks	8	4	4	5
not hard	6	2	6	7
try hard	1	2	3	0
feedback	1	0	0	4
parents good	0	3	0	1
enjoy it	0	1	1	1
streaming	2	3	0	0
position in class	0	0	0	1
confidence	0	0	1	1
best subject	0	0	0	1

Among students with low talent perceptions at odds with high maths performance, the most common responses given by boys (group 5, see Table 3) was that they made no effort (n=4), had a low position in the class (n=3), had low confidence (n=2) or expended high effort which did not result in high marks (n=2). There was a single mention for each of maths being hard, needing high effort, maths being boring, streaming and maths being their worst subject. For girls (group 6, see Table 3), most cited maths being hard as their reason for

having low talent perceptions (n=6), with other common responses being low marks (n=5) and maths being boring (n=4). Two girls in each case cited needing to expend high effort, having a low position in the class, and making no effort. There was a single mention in each case of negative feedback, streaming, maths being their worst subject and expending high effort that did not result in high marks.

Table 3

Responses to Open-Ended Question about why Students Felt Untalented at Maths (groups 5-6)

	boys - G5	girls - G6
low marks	0	5
hard	1	6
need high effort	1	2
feedback	0	1
boring	1	4
streaming	1	1
position in class	3	2
low confidence	2	0
worst subject	1	1
don't try	4	2
try hard but don't do well	2	1

Possible Frame of Reference Effects for Students' Talent Perceptions

Clearly, many of the boys and girls having erroneously high talent perceptions (groups 3 and 4 respectively) think they perform well at maths. To understand why this might be the case, students were asked with whom they compare themselves when deciding how talented they think they are at maths. Boys mostly compared themselves with their friends (n=6), with other reference groups being their family (n=3), their class (n=2), students in higher classes (n=2), their level (Advanced, Intermediate or General, n=1). Girls mainly compared themselves with their class (n=5), then their friends (n=3), with few students (n=1 in each case) having family, students in higher classes and students in lower classes as their reference group. A theme that emerged for these girls was the use of ego-protective strategies in order to interpret their performance as positively as possible. Consider Hannah's response when asked with whom she compared herself when deciding how talented she thinks she is:

Hannah: People in my classes.

Int: In other classes?

Hannah: Yep.

Int: Which classes?

Hannah: I don't know. Either people in higher classes or those who are in Advanced maths. It really depends on, if I want to compare myself,

if I get a bad mark I compare myself with people in lower classes,

if I get a good mark I compare with people in higher classes.

Interestingly, this was also characteristic of girls having high talent perceptions and high achievement. For example, Angelica stated:

Angelica: I think I'm just comparing myself to the rest of the maths class or the rest of the year. Like if I was going to rate myself, I would rate myself third.

Int: Against the class or the year?

Angelica: Probably against the class more than the year.

Int: Are most of your friends in your maths class?

Angelica: I've got three. There aren't that many girls in my maths class and most of my friends are in the top class, maybe a couple in the lower maths class.

Int: So you don't compare yourself with your friends particularly?

Angelica: Sometimes. I don't feel particularly good about it - I try not to.

and Tamara (also from group 2):

Int: And which other people do you compare yourself with?

Tamara: The friends I have.

Int: Are your friends mostly in your class?

Tamara: No.

Int: Okay, so you compare yourself mostly with your friends. Is that right?

Tamara: Yeah.

Int: Well that's interesting - so not with your class?

Tamara: No. I feel much better comparing with my friends.

This seems a plausible contributing explanation as to why girls with erroneously high talent perceptions might consider their performance to be high, but it is interesting that high achieving girls with high self-perceptions (group 2) would adopt the same strategy. As for the boys, it is possible that friends serve a buffering role, in that they would be a supportive reference group. Thus the boys with erroneously high talent perceptions may be indulging in a similar strategy to the girls. A characteristic of the high-achieving boys with high talent perceptions that was not evident in other groups was the positive effect of competition. For example,

Ben: I compete with people I sit with usually.

Int: So it's like a healthy rivalry to beat them?

Ben: Sort of, yeah.

Int: Do you study harder so you can beat these people?

Ben: A bit, yeah. I work a bit harder.

Int: Do you?

Ben: Bit of competition.

and

Tim: There's one person who I have always been close to in maths and I always compare myself against him. In tests he gets the same as me, but one or two marks different in every test.

Int: And if he beats you, how do you feel?

Tim: I have to beat him next time.

It seems this rivalry is not a stressful factor for these boys, but rather a motivating and even enjoyable force. This is illustrated nicely by Don.

> Don: I compare with my friend who is really a best friend...our talents are about the same, so we study and compare to each other, and it was fun.
>
> Int: And you compared your talents according to how you went?
>
> Don: Yes. We started betting each other with a can of coke - it was fun.
>
> Int: That competitive nature - did that work?
>
> Don: Yeah, it did work - and once I was one mark below him and I was really angry, but it was fun.

For students having low talent perceptions at odds with their high achievement, there is a clear difference between these girls and girls from the other two groups. While girls with high talent perceptions adopted ego-protective strategies in the form of reference groups that highlighted their ability, girls from the low talent perception group indulged in direct comparisons with people against whose ability theirs appeared less. Consider Rebecca:

> Int: When you are forming this opinion about how good at maths you are, who do you compare with?
>
> Rebecca: Just my friends I hang around with, how good they are at their work and how good I am.
>
> Int: And how do you compare with them?
>
> Rebecca: Um... they are all in the top classes compared with me.

Boys with low talent perceptions, as for the boys with erroneously high talent perceptions, mostly compared themselves with their friends (n=5), with other frames of reference being their class (n=2), siblings (n=1) and own previous performance (n=1). It does not seem clear how the frame of reference could then contribute to differences in perceptions between boys.

Reasons for Students Having *Always* Felt the Same about their Maths Talent or Having Changed their Perceptions

Students with High Talent Perceptions and High Maths Achievement. Most students holding high talent perceptions commensurate with their maths achievement had not always felt the same about their maths talent (group 1: n=6, group 2: n=7). For boys, points at which their perceptions had become more positive were gradually through high-school (n=3), as they tried progressively harder and their performance improved. One boy's talent perceptions fluctuated based on his performance, being more positive or negative

depending on his marks. Other idiosyncratic responses related to one boy having moved from Hong Kong to Australia and finding maths easier here, and another whose talent perceptions had actually declined towards the end of the previous year due to English language difficulties as maths became increasingly more language-based. Boys whose perceptions had always been similar gave reasons as always having been good at maths (n=2) and always having been in top classes (n=2).

Sources of changes in high-achieving girls' high talent perceptions were on beginning Year 9 (n=2), when the greater content difficulty of the Advanced level resulted in a slight decline in perceived talent. Ego-protective strategies in the form of attributed modifying external factors were again evident with these students, resulting in their talent perceptions staying high. Susie illustrates this strategy:

> Int: Have you always felt that you were talented at maths?
>
> Susie: Yeah.
>
> Int: So there's no stage where you suddenly felt that -
>
> Susie: - well at the beginning of Year 9 the courses are much harder, and I felt my marks... but we were all warned of that.

Two girls' perceptions increased due to expending greater effort, one on commencing high-school and the other in Year 6. Other reasons related to one girl having missed lots of school in Year 6 and experiencing difficulties as a result, and another moving to Australia in Year 6 and finding the maths easier here. Girls having always felt the same about their maths talent gave their reasons as being due to always having done well (n=1), always having been in top classes (n=1) or maths always having been their best subject (n=1).

Students with High Talent Perceptions and Low Maths Achievement. Most students holding high talent perceptions at odds with their maths achievement had always felt the same about their maths talent (group 3: n=7, group 4: n=6). Most boys attributed their consistently high perceptions to always having done well (n=4). Other responses were enjoyment (n=1), finding it easy (n=2), being a quick worker (n=1) and high confidence (n=1). Boys whose talent perceptions had at some point changed (n=3) all attributed this to some form of better teaching, being a tutor in Year 7, good teachers in Year 7, and a good teacher this year for each of the three boys.

For the six girls consistently perceiving themselves as highly talented at maths but having low measured achievement, most cited feeling they understood maths well as the main reason (n=3), with the only other reason given being high marks (n=1). Among the four girls whose talent perceptions had changed, two attributed this to increased effort (one this year and one gradually throughout high-school), a theme that also emerged among the high-

achieving girls with high perceptions (group 2). Another girl's talent perceptions fluctuated depending on her most recent result, and the fourth girl's reported perceptions had declined slightly the previous year due to a poor teacher.

Students with Low Talent Perceptions and High Maths Achievement. Most boys having low talent perceptions at odds with their high measured maths achievement had always felt the same way (n=6). However, more girls having low talent perceptions but high performance could identify a point at which their perceptions had changed (n=8). Reasons boys gave for having consistently low perceptions were knowing they were stupid (n=1), always having had trouble understanding (n=2), always having done badly (n=1) and always having found maths harder than other subjects (n=1). For boys whose perceptions had changed, two said their perceptions fluctuate based on their performance, one said his perceptions had increased slightly on commencing high school as he worked hard and improved, and another stated his perceptions had declined on starting high-school due to English-speaking difficulties becoming more salient in maths.

Girls attributed changes in their talent perceptions to maths getting harder in either Year 7 (n=1) or Year 9 (n=3), to poor teaching in Year 8 (n=1), streaming in Year 8 (n=1), disruptions from changing Primary schools (n=1) and one girl's perceptions fluctuated based on each test result. Of the two girls whose low talent perceptions had been constant, one gave the reason as being due to lack of enjoyment, with the other saying maths was her worst subject.

Significant Others' Views about Students' Maths Talent

Students were asked whether most people thought they were talented (or not talented for groups 5 and 6) at maths. Follow-up probes relating to parents, teachers and friends were used if these were not mentioned initially. Responses within each group are reported separately for unprompted and prompted responses.

For students with high talent perceptions (groups 1 to 4), the most common initial group mentioned in response to the question 'do most people think you are talented at maths?' was friends, with the next most common group referred to being parents (see Table 4). Peers and classmates were referred to mostly by girls having high perceptions and performance (group 2), and teachers mostly by boys with erroneous high perceptions (group 3). References to teachers and parents were less salient for unprompted responses, but emerged in response to the follow-up probes. That fact that friends were the most accessible group does not necessarily imply it is the most important, which is why the subsequent interview question asked about the relative influence of each group.

Table 4

Frequency of Significant Others' Reported High Talent Perceptions (groups 1 to 4)

	Unprompted Responses				Total Responses			
	boys-G1	girls-G2	boys-G3	girls-G4	boys-G1	girls-G2	boys-G3	girls-G4
friends	4	6	4	5	6	9	5	5
parents	3	3	2	4	9	10	6	8
teachers	0	1	2	1	7	5	8	5
classmates	1	3	0	2	1	3	0	2
peers	1	3	1	1	1	3	1	1

In response to follow-up probes, the most common group to which positive talent perceptions were attributed was parents followed by teachers. Summation of unprompted and prompted responses within each group yields totals indicating how many students in each group feel significant others have positive perceptions of their maths talent (with a possible maximum of 10 in each case). Clearly the most frequent group for students with high perceptions and performance is parents (groups 1 and 2), while for students having erroneously high perceptions the most common group for girls is parents, while for boys it is teachers (groups 4 and 3). A theme that emerged for these boys citing teachers as having positive talent perceptions, was that they tended to construe encouragement as their teachers thinking they were talented. For example, Peter interprets positive reinforcement for attentive behaviour in this way:

> Int: Do the teachers think you're talented at maths?
>
> Peter: Yeah.
>
> Int: What sort of things do they say to make you think that?
>
> Peter: Things like I work hard in class and other people are mucking around, but I tend to sit down and do my work.

and John does the same with teacher encouragement:

> Int: Now, do most people think you're talented at maths?
>
> John: I don't really discuss it with lots of other people, but the teachers usually say "you're working hard" or "you're getting good".

It is notable that the exact opposite interpretation occurred with high-achieving girls having low talent perceptions. Gwen, for example, interprets direct positive feedback in a negative way:

> Gwen: I don't know... People usually just don't want to put me down so they just say that you're doing pretty well.

and Mandy makes no inferences of high talent perceptions from others' encouragement, in fact believing them to consider her untalented:

> Mandy: Well the people in my class think that I'm good at maths, but people outside, they encourage me, but they - I'm sure they think that I'm not good at it.

A theme that emerged for girls having high talent perceptions when referring to their peers, was being made fun of. This emerged for both girls of high and low achievement (groups 2 and 4). Susie is an example from group 2:

> Int: Do most people think you're good at maths?
>
> Susie: Yeah. It's embarrassing sometimes because I get called silly names, but you know - just for fun from friends. It's like embarrassing - not anything bad, because I know they're just joking. They don't mean anything.

and Sarah from group 4:

> Int: Do most people think you're good at maths?
>
> Susie: My friends just say, just as a joke and all that, "you're in the top class". But only as a joke.

In addition, one boy from group 1 mentioned classmates and another mentioned peers as having negative perceptions of their talent without being prompted. Ten other students distributed over the four groups mentioned significant others having negative perceptions following prompting.

For students with low talent perceptions (groups 5 and 6) there was also a mixture of reported views of significant others being both positive and negative. In response the open-ended question 'do most people think you are not talented at maths?', one boy cited parents and another siblings as perceiving them as untalented, while 4 girls cited parents, one friends, one teachers and another siblings as having low talent perceptions in relation to the students. However, boys mentioned friends (n=4), peers (n=2) and parents (n=1) as holding positive perceptions, while girls mentioned friends (n=3), parents (n=3), peers (n=1) and classmates (n=1) as having high talent perceptions of themselves.

Following prompting, boys with low talent self-perceptions cited parents (n=4), friends (n=1), teachers (n=1) and siblings (n=1) as holding low perceptions of their talent, while girls cited parents (n=2) and friends (n=1). Positive perceptions were reported by boys for friends (n=2) and teachers (n=2). Girls gave more responses than boys, with positive perceptions reported in relation to teachers (n=7), friends (n=2), parents (n=2) and peers (n=1). Summations of unprompted and prompted responses for groups 5 and 6, separately for reported negative and positive perceptions are shown in Table 5.

Table 5

Total Frequency of Significant Others' Reported Talent Perceptions for Students with Low Talent Perceptions and High Achievement

	Negative Responses		Positive Responses	
	boys-G5	girls-G6	boys-G5	girls-G6
friends	1	3	4	5
parents	5	5	3	5
teachers	1	0	2	7
classmates	0	0	0	1
peers	0	0	2	2
siblings	2	1	0	0

For boys and girls it is parents that are the most common group holding negative talent perceptions. For boys, friends are seen as most frequently holding positive perceptions, while teachers are for girls. It is worth noting, however, that many of these girls were not too sure what their teacher's attitudes were, often basing their interpretation of teacher perceptions on minimal report communication, or projecting judgements based on their own interpretation of objective performance indicators, even if they did say their teachers thought they were talented at maths. Heather is an example of a high-achieving girl with low talent perceptions basing her interpretation of teacher perceptions on minimal information:

> Int: What about teachers? Do they think you're good at maths?
>
> Heather: I think they think I'm okay. They haven't said that they're unpleased or anything.

Jenny is another girl from this group basing her perceptions of teacher attitude on minimal report communication:

> Jenny: Yeah. I think they think I'm pretty good.
>
> Int: Okay, how do you know that?
>
> Jenny: In the report, she wrote it.

and Gwen illustrates the tendency to project perceptions onto the teacher based on objective performance indicators:

> Gwen: I think the teachers... well my maths teacher thinks - I'm in the top of the class - so I think she thinks I am doing better than I have because I had her last year as well and I went down from there, and I think I'm going back up, so I think she thinks I'm improving but I can still do better.

Relative Influence of Significant Others' Perceptions on Students

Students were asked whose views actually influenced their own perceptions of mathematical talent. Follow-up probes addressing parents, friends and teachers were used if these groups were not mentioned initially. Students did not necessarily rank these three groups from 1 to 3, since there were instances where students stated particular groups had no effect on their perceptions at all. In these cases, students may have ranked two groups but omitted the third, for example. The groups students stated as influencing their perceptions are presented in Table 6 in order of strength of effect. The strongest influence for group 1 was parents, for group 2 was teachers, for group 3 was the self and for groups 5 and 6 were parents. Note that the self and siblings were not sources suggested by the interviewer, but raised by individual students. A weighted total was computed to summarise the strength of influence of each source within each group of students. A 3:2:1 weighting was applied for strongest : second strongest : third strongest sources resulting in a possible maximum of 30 for each source. The strongest total influence for group 1 was parents, for group 2 was teachers, group 3 was parents and the self, group 4 was parents, group 5 was the self and group 6 was parents. Parents were perceived as exerting a strong influence for all groups excepting group 5, and friends were reported to exert moderate influence for all groups excepting group 4.

Table 6

Relative Influence of Significant Others on Students' Talent Perceptions

		boys-G1	girls-G2	boys-G3	girls-G4	boys-G5	girls-G6
strongest	parents	6	3	3	5	1	7
	friends	3	3	1	0	3	1
	teachers	1	4	0	3	1	0
	myself			5		5	2
	siblings			1			
2nd strongest	parents	2	3	3	2	1	1
	friends	4	2	2	1	2	4
	teachers	2	5	2	2	1	2
3rd strongest	parents	1	2	0	0	1	0
	friends	0	1	0	0	0	1
	teachers	2	0	1	0	0	2
	myself					1	
WEIGHTED	parents	23	17	15	21	6	23
TOTALS	friends	17	16	9	2	13	12
	teachers	9	22	5	13	5	6
	myself			15		16	6
	siblings			3			

DISCUSSION

The three major research questions this study aimed to investigate were first, what factors are facilitative of high-achieving girls having commensurate talent perceptions in maths. Second, what factors contribute to low-achieving boys having high perceptions of talent, and most importantly, what are the deterrents to high-achieving girls having high talent perceptions. The second question was included as it was thought the same forces operating in gender-differentiated ways might be responsible both for low-achieving boys having high talent perceptions and high-achieving girls having low talent perceptions.

What Factors Facilitate High Talent Perceptions for High-Achieving Girls?

High-achieving girls with commensurate talent perceptions tended to base this mostly on objective indicators, such as high marks and being in a high stream. This was also true of the parallel boys' group, with the only notable difference being that the girls also attributed their talent to their parents being good at maths. This was an unexpected response, perhaps

indicating these girls saw maths talent as reflecting an inherited ability. Most girls were able to identify a point in time at which their talent perceptions had changed, as were the boys, these being upon exerting more effort and performing better as a consequence, and in the case of the Asian student moving to Australia, due to finding maths easier here. The two instances of declines in perceptions were attributed to external factors such as Year 9 maths being objectively harder for everyone, and disruptions to schooling. These attributions were similar to those of boys. Both girls and boys whose perceptions had remained stable gave objective reasons as being due to always having obtained high marks and been in top classes.

High-achieving girls with high perceptions of talent adopted ego-protective strategies that were not evident for the boys. These were in the form of a protective reference group, such as lower-achieving friends, comparison with which cast their abilities in a very positive light. Another example was in externalising perceptual changes, such as finding maths increasingly difficult, so that they interpreted this in a non-personal way, since it was an objective phenomenon applicable to everyone. These strategies were not apparent for the boys' group, perhaps indicating that the girls were sensitive to factors that were either aimed at them or that the boys were unaware of, against which they needed to buffer themselves in order to preserve their high self-perceptions. The joking theme that emerged for girls, whereby peers made taunting or derogatory comments about the girls' high achievement, may well be an example of this, with the interpretation of these as only jokes being the buffering mechanism. This theme did not emerge for the boys, but the enjoyment of competition may well be its parallel. Perhaps the girls, but not the boys, are embarrassed by their high achievement, possibly due to high maths ability being seen as desirable for boys, but unsuitable for girls. This could result in the girls shrugging off taunts as jokes, and the boys meeting the challenge through competing.

These girls were the only group that attributed great strength of influence on their talent perceptions to teachers (weighted total of 22/30), which is consistent with the pattern of using objective indicators to base their perceptions on. However, only half the girls in this group thought their teachers perceived them as talented, with the others being unsure what their teachers' views were. Although all these girls reported their parents perceiving them as talented, and all but one reported the same for their friends, these sources had only moderate influence on these girls' perceptions (weighted totals of 17 and 16), perhaps because they were perceived as not objective. Boys, on the other hand, both most frequently cited parents as thinking them talented at maths, and also were most strongly influenced by them.

Why do Low-Achieving Boys Have High Talent Perceptions?

Most of the boys having erroneously high talent perceptions attributed their self-perceptions to not finding maths difficult, with other common responses being performing well and trying hard. It is possible, since this group compared themselves mainly with their friends, that performing well and not finding maths difficult are relative to these friends, and hence may well inflate talent perceptions. It is interesting that these boys see expending high effort as an indicator of maths talent, and indeed other students (group 6) perceive the need to expend high effort as indicating lack of talent, as will be discussed later. These attributions were similar for the parallel girls' group, with the exceptions of the girls not citing high effort,

but referring to positive feedback from significant others. This last may indicate greater sensitivity on the part of girls to external stimuli. Alternatively, it may suggest these girls, but not the boys, actively seek out the viewpoints of significant others. It is possible this may be an ego-protective strategy, in view of the fact that their performance is not high. Certainly these girls tended to adopt other ego-protective, or even self-enhancing strategies in the form of a protective frame of reference, as did the high-achieving girls with high talent perceptions. Similarly, the joking theme was evident with this group of girls as with the high achievers.

Most boys in this group had stable talent perceptions, with explanations being high performance, not finding maths difficult, enjoyment, being a quick worker and having confidence. The first two of these may be derived, as has been suggested, in relation to friends, explaining the apparent disparity between low objective achievement measures and high perceptions of achievement. It is possible this is an ego-protective strategy employed by the boys. Enjoyment and confidence are non-comparative factors, and speed fairly so, and hence additional plausible explanations for these boys' high perceptions. Girls with stable perceptions in the parallel group attributed these mainly to good understanding of material in maths, with one reference to high performance also. Understanding is also a self-referent construct, and hence a plausible rationale for the girls' erroneous high perceptions.

Consistent with the emergent theme of non-comparison for these boys, they attributed the strongest influence on their talent perceptions as being jointly themselves and their parents (weighted totals of 15/30). Girls cited parents as having the greatest effect on their perceptions, which is also the group they most frequently cited as considering them talented. This is consistent with the notion of ego-protection suggested for girls basing their talent perceptions on feedback from significant others. It is not clear whether the girls seek out positive feedback from their parents, or whether the parents offer it regardless. This could be established by documenting the nature of parents' feedback, and noting whether the girls interpret encouragement or neutrality as high talent perceptions. If not, it would be useful to ask parents their internalised versus vocalised perceptions of their daughters, and motives for any mismatch. In the event of no mismatch, research should address reasons for why these parents consider their daughters talented at maths, with possibilities including withholding of information by their daughters.

Boys tended to interpret encouragement as synonymous with high talent perceptions, as was evident through analysis of their reasoning for considering teachers as perceiving them to be talented. All but two of the boys thought their teachers perceived them to be talented, although evidence for this was in the form of encouragement for appropriate behaviour or effort.

Why do High-Achieving Girls Think they are Not Talented at Maths?

High-achieving girls with low talent perceptions based these mainly on poor performance, finding maths difficult and finding it boring. Also, contrary to boys with high talent perceptions at odds with their low achievement, girls in this group perceived the need for effort expenditure as indicative of lack of maths talent. Despite objectively high measured

mathematical achievement, the frames of reference these girls employed in interpreting their achievement cast it in a negative light. Girls in this group tended to explicitly compare themselves with others against whose performance theirs appeared worse. This is in direct opposition to girls from the other groups who tended to choose a protective reference group to maximise their interpretation of their own achievement. Boys in the parallel group based their talent perceptions on a different set of factors, being mainly lack of effort and a low position in the class. This last may be indicative of a tendency on the part of these boys, not to actively make comparisons with groups against whose performance theirs appears worse, but at least to not buffer their perceptions by seeking out a reference group against whose achievement theirs is highlighted.

Most girls could identify a point in time when their perceptions had changed, being mostly upon finding maths harder (in Year 7 or 9), with other reasons given as being streamed and not put in a top class, poor teaching or disruptions to schooling. The two girls whose perceptions had remained stable attributed this to not enjoying maths and maths being her worst subject. In contrast, boys in the parallel group mostly had stable talent perceptions, with the only instances of change being one boy whose perceptions fluctuated based on each test result, another who was having English language difficulties as maths became more vocabulary based, and one whose perceptions had increased based on greater effort expenditure. Most boys having stable talent perceptions attributed these to always having done badly, having poor understanding and having maths as their worst subject. It is interesting that talent perceptions remained largely stable for the boys, while most girls could identify some point at which their perceptions had changed. This may reflect greater contextual sensitivity for girls, or at least, greater awareness of their perceptions and related influences in order to have been able to identify the change point.

Girls underestimating their maths talent cited parents as most frequently holding negative perceptions of their talent, although an equal number (five) cited parents as holding positive talent perceptions. The group mentioned with the greatest frequency as holding positive perceptions was teachers. It is important to note, however, that these girls were often unsure of their teachers' views, basing their perception on minimal information, lack of negative feedback, or projecting reasoned views onto teachers, based on objective performance indicators. Teachers exerted little effect on the perceptions of these girls in any case, with the main influence coming from parents. It would be interesting to compare the messages given by these parents with those given by parents of overestimating girls, to examine whether the difference is due to opposing feedback, or to differential interpretation by the two groups of girls. Boys in the parallel group also cited parents with the greatest frequency as holding negative talent perceptions, and friends as holding the most positive perceptions. The strongest influence on their own perceptions, however, was the self, followed by friends (weighted totals of 16 and 13/30).

Conclusions

The inclusion of parallel gender groups to each of the three focal groups enabled gendered comparisons to be drawn within each condition. Comparisons between the three focal groups are now made in order to address the central research question of the study, namely: why is it that high-achieving girls have low self-perceptions of talent? Comparison with high-achieving girls holding commensurate talent perceptions enables identification of factors that

are facilitators versus deterrents to these girls having high talent perceptions. Comparison of high-achieving girls having low talent perceptions with the group of boys holding high self-perceptions at odds with their low measured achievement addresses the question of whether similar forces act in gender differentiated ways, resulting in opposite effects for boys and girls, whereby low-achieving boys overestimate, and high-achieving girls underestimate their maths talent.

In contrasting emergent themes for the two groups of high-achieving girls, the most striking difference is the adoption of ego-protective strategies in the form of a protective frame of reference by the girls with high talent perceptions, and the comparison with groups against whose achievement these girls' appears worse, for the girls having low talent perceptions. Another difference lies in the emergence of the joking theme for those holding high perceptions, versus its absence for the other girls. Perhaps girls having low talent perceptions are as susceptible as other girls to negative external stimuli, but unlike girls in the other two groups, have no protective defence mechanism to buffer such influences. These girls may not interpret taunts about their performance as jokes for example. Finally, girls with high perceptions of talent tended to base these on mostly objective indicators such as high marks, streaming and teacher influence; while girls having low talent perceptions tended to base these on more affective indicators such as finding maths hard and boring. Low marks were also a frequently stated reason, but the difference in reference groups employed by the two groups of girls may explain the differential performance interpretations made of similarly high maths achievement. It is likely that objective indicators of talent are more stable and influential than affective indicators, which are largely self-referent, and consequently not necessarily reflective of objective achievement.

As anticipated, it was indeed the case that diametrically opposed factors were evident in the group of high-achieving girls with low talent perceptions, and the low-achieving boys with high talent perceptions. First, the boys interpreted encouragement by significant others as reflective of them holding high talent perceptions, while the exact opposite was true of the girls. In fact, these girls interpreted encouragement as masking negative perceptions of their maths talent. This lends support to the notion of these girls being highly contextually sensitive. Another contrast was evident in that these boys interpreted high effort expenditure as indicative of high talent at maths, while the girls interpreted the need for high effort expenditure as reflective of low maths talent. Finally, the boys perceived maths as enjoyable, while the girls found it boring. It seems that encouragement from significant others, effort expenditure and the content of maths are operating in gender differentiated ways, such that the same forces are exerting positive effects on low-achieving boys, and negative effects on high-achieving girls. Further research is needed to explicate the content and nature of encouragement from significant others to boys and girls, to explore boys' and girls' conceptions of implications of effort expenditure, and to examine why boys see maths as enjoyable and girls see it as boring. Much research has looked at sex-typed messages contained in maths textbooks and teaching methods, and these may well contribute to the findings here (for example, Scott & McCollum, 1993; Eccles & Blumenfeld, 1985). Results of attributional retraining also make it plausible that girls' interpretations of effort expenditure could be changed.

In summary, the main differences between high-achieving girls holding high versus low perceptions of mathematical talent appear to lie in the adoption of ego-protective strategies

by the former. In addition, gender differentiated messages may account for girls' perceptions being negatively and boys' positively affected. Implications for policy and practice may include the explication of identified influential forces to girls, so that they are aware of contextual pressures and can develop ego-protective strategies. Also, it may be fruitful for teachers to provide more objective indicators of high-achieving girls' abilities, so that they base their talent perceptions on non-affective and non-subjective information. With reference to the gender differentiated messages and effects, parents and teachers could be advised as to the most constructive ways to encourage high-achieving girls. It may also be possible to retrain these girls' conceptions of effort expenditure such that they do not perceive this as a negative. Finally, the content and methods of teaching maths need to be further explored to understand how the subject should most equitably be presented.

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