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# Strategic Decision-Making and Social Skills: Integrating Behavioral Economics and Social Cognition Research

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**Abstract:** Strategic decisions are affected by beliefs about the expectations of others and their possible decisions. Thus, strategic decisions are influenced by the social context and by beliefs about other actors' levels of sophistication. The present study investigated whether strategic decision-making, as measured by the beauty contest game, is associated with social skills, as measured by the Autism Quotient (AQ). In line with our hypothesis, we found that social skills were positively related to successful strategic decision-making. Furthermore, results showed a curvilinear relationship between steps of reasoning in the beauty contest game and social skills, indicating that very high as well as very low scoring individuals on the social skills subscale of the AQ engaged in high-levels of strategic thinking.

**Keywords:** strategic decision-making; beauty contest game; social skills; behavioral economics

**JEL Classification:** C72; D03; D83

## 1. Introduction

In many decisions in social contexts, the outcome of a choice option is dependent on the option chosen by the other actors. In this case, the preferred option is not solely based on the actor's preferences but also on the others' preferences and the others' resulting choice. Therefore, such decisions are strategic in nature. Strategic decisions have traditionally been considered a result of rational thinking (Von Neumann and Morgenstern [1]), but it is now assumed that strategic decisions are also influenced by the social context and affected by beliefs about other actors' levels of sophistication as shown, for example, by Bosch-Doménech et al. [2] and Costa-Gomes and Weizsäcker [3]. The present paper argues that the level of sophistication reflected in strategic decision-making is affected by the ability to put oneself into the mind of the other, which is key for successful social interaction (Rose-Krasnor [4]). Hence, we examine whether strategic decision-making is associated with the social skills of the decision maker. Social skills entail a diverse array of skills that facilitate interaction and communication with others and are linked with the ability to make inferences about mental states of others (Baron-Cohen et al. [5]).

Behavioral economists developed the so called "beauty contest game" (Nagel [6]) in order to investigate the iterative steps of thinking during strategic decision-making (i.e., "what you think the others think about what you think") which capture strategic reasoning. In the beauty contest game, $n$ participants are asked to simultaneously pick a number $x_i$ in the interval [0; 100] that he or she assumes to correspond to the average of all the numbers multiplied by a multiple $p < 1$ (e.g., $p = 2/3$).

The player whose number is closest to that target number (i.e., 2/3 of the average) wins the game and receives a prize (Nagel [6], Ho and Camerer [7]). The numbers participants guessed are used to infer their level of reasoning about others. Levels of strategic reasoning capture the level of beliefs an agent holds about other agents, and are referred to as level-K (Shapiro et al. [8]). Individuals differ with regard to how many iterated steps of reasoning they typically carry out: Individuals who carry out no steps of reasoning (so-called level-0 individuals) pick random numbers. In contrast, level-1 individuals assume that all others behave as level-0 players, which have a mean of the numbers picked around 50, and hence, level-1 players pick a number around 50 × 2/3 = 33 (if $p$ = 2/3). In the same vein, level-2 individuals suppose all other players to show level-1 reasoning and, hence, pick a number around 33 × 2/3 = 22. Level-3 players choose a number around 22 × 2/3 = 15, and so forth. The Nash-equilibrium of the beauty contest game with the parameters given above would be zero.

Previous studies have shown that a high level of strategic reasoning (as measured by the beauty contest game) is positively associated with cognitive abilities. Cognitive abilities entail a range of different psychological constructs, such as working memory and general intelligence. They are likely to determine the ability to think about the other players' moves, mentally simulate them, and determine the best response in an iterative process. Evidence for this assumption comes from studies showing that higher working memory capacity (Rydval [9]), higher general cognitive ability (Burnham et al. [10], Carpenter et al. [11], Gill and Prowse [12]), and higher cognitive effort (Brañas-Garza et al. [13]) are associated with strategic decision-making. Furthermore, Carpenter et al. [11] found causal evidence by manipulating cognitive abilities and thereby changing the level of strategic sophistication.

At the same time, it is important to note that very high levels of sophistication do not necessarily mean that individuals are likely to be successful in strategic interaction since very high levels of sophistication can reflect an overestimation of the opponents' degree of sophistication. To illustrate, picking the number 0 or a number very close to 0 in the beauty contest game, while reflecting a very high degree of sophistication, does not indicate a high degree of strategic thinking, since it is based on the questionable assumption that all (or almost) all of the other players behave fully rationally. Therefore, an impairment to forming beliefs or forming inadequate beliefs about others will result in strategies reflecting high sophistication, but result in strategically suboptimal (i.e., unsuccessful) decisions. As a consequence, cognitive ability appears to be only one important aspect that determines success in strategic interactions. Its complementary process is the ability to adjust one's beliefs according to the other players' putative beliefs, which is based on theory of mind (ToM). ToM, or mentalizing, is the ability to make inferences about mental states of others (Premack [14]).

The influence of ToM is evident in a study by Agranov et al. [15], in which participants were asked to make strategic decisions with varying opponents and found that decisions changed dependent on the opponent faced. Furthermore, Georganas et al. [16] showed that a measure assessing ToM, the "Reading the Mind in the Eyes" task (Baron-Cohen [17]), correlated with level-K (specifically, level-0 Eye Gaze scores were significantly lower than those of levels 2, 3, or Nash scores, and level-1 scores were significantly lower than level-2 or Nash scores), thereby suggesting that level-0 and level-1 players are less able to consider other persons' beliefs and strategies. The present study aims to build on and extend this line of research by examining the link between strategic decision-making and social skills. Social skills (also termed interpersonal skills or social intelligence) can be defined as the ability to effectively and appropriately interact with other people. Whereas measures of ToM, such as the "Reading the Mind in the Eyes" task, assess highly specific aspects of social cognition (e.g., the ability to infer the mental state of a person just from the information in photographs of a person's eyes), social skills can be seen as a broader construct subsuming a diverse array of skills that facilitate interaction and communication with others.

### 1.1. Theory of Mind as a Central Process for Successful Strategic Decision-Making

The notion that mental state attributions and associated social skills are relevant for successful strategic decision-making has received indirect support through a functional neuroimaging study showing a positive correlation of activity change in brain areas previously associated with social cognition and ToM (i.e., the medial prefrontal cortex) and levels of strategic thinking in the beauty contest game. In particular, the data show that a measure of successful decision-making (related to winning in the game) correlated with neural activity in the medial prefrontal cortex (Coricelli and Nagel [18]). Furthermore, in another study employing a strategic interaction task from behavioral economics (the so-called stag hunt game), it was found that individuals showing an impairment of ToM compared to controls were less successful in cooperating with others (Yoshida et al. [19]). Finally, Bruguier et al. [20] found that skill in forecasting price changes in markets with insiders was correlated with ToM abilities. While this latter study shows the importance of mentalizing for predicting others' actions, it does not show that the predictions about others are also used during strategic decision-making. Assuming that the impact of ToM on predictions and beliefs are identical with its impact on social choices seems farfetched since, as a recent study shows, impairments of social skills do not affect learning or the processing of social cues, but their use in decisions (Sevgi et al. [21]).

### 1.2. Strategic Decision-Making and Autistic Traits in Normal Adults

Interestingly, an impairment of mentalizing and strategic decision-making has been found to be closely related to impairments of social skills and social interaction in autism according to the 5th Edition of the Diagnostic and Statistical Manual of Mental Disorders issued by the American Psychiatric Association [22]. It is also assumed that autistic traits vary across the normal population in line with the idea of an autism spectrum (Baron-Cohen et al. [5]). Consequently, even individuals without a diagnosis of autism differ in the scores on the Autism Quotient (AQ) (Yoshida et al. [19]), a well-established psychometric test used to assess autistic traits. In contrast to the notion that high autistic traits are always associated with a ToM deficit, it has been shown that high-functioning individuals with autism show a dissociation of explicit and implicit mentalizing abilities: while they are able to explicitly mentalize what others do and may even spend more time mentalizing than low AQ individuals (Senju et al. [23]), they are impaired to form adequate mental representations of the specific other in the ongoing social interaction and to use them during social decision-making (Sevgi et al. [21]).

### 1.3. The Present Study

The present study seeks to shed light on the question of whether strategic decision-making, as measured by the beauty contest game, is associated with social skills. So far it is implicitly assumed that social skills are closely related to strategic decision-making. As noted above, this assumption receives indirect support in the literature. In strategic social interactions humans adjust their strategy to their opponent (Agranov et al. [15], Slonim [24]), success in strategic decisions is associated with activations of the so-called ToM (or social cognition) network (Coricelli and Nagel [18]) and the accuracy of predictions in markets yielding insider trading were linked to ToM (Bruguier et al. [20]). Furthermore, strategic thinking was associated with correctly interpreting emotional expression of others (Georganas et al. [16]). However, the hypothesis that strategic decision-making is associated with social skills has not been tested directly.

Two reasons indicate the necessity for such a study: First, the brain areas identified in the neuroimaging study of Coricelli and Nagel [18] are also associated with prospective memory (Buckner and Carroll [25]), meaning any form of mental simulation, not necessarily only a social one. As a result, just the mere simulation of iterative steps in the game could have resulted in the activation of the respective brain areas, without reflecting the social aspect of it. Second, predictions are central for forming beliefs about others in social interactions and are affected by the ability to mentalize

(Bruguier et al. [20]), but individuals who vary in their autistic traits do not show impairments of the ability to form beliefs but to use these beliefs when making social decisions (Sevgi et al. [21]).

Importantly, most research examining the role of ToM and social skills for strategic interaction is found in clinical neuropsychology investigating the role of autistic traits for one important aspect of autism, namely impairment of ToM. In line with this research tradition, we decided to employ a standard self-report measure used in previous studies to measure social skills (Sevgi et al. [21], Senju et al. [23], Schneider et al. [26]). Specifically, we conducted a correlational study with a student sample measuring strategic decision-making on the one hand (by employing the standard beauty contest game) and the AQ (Baron-Cohen et al. [5]), which measures autistic traits in adults of normal intelligence that are associated with ToM and social skills. The AQ (Baron-Cohen et al. [5]) includes questions evaluating both social and non-social domains and examines cognition, behavior, ability, and preferences in a forced-choice format. The 50 items of the AQ are divided into five subscales consisting of 10 items each that assess domains of social-cognitive strengths and difficulties: social skills, communication, imagination, attention to detail, and attention switching.

We assume that social skills as measured by the AQ are particularly important to make successful strategic decisions since they allow for forming adequate beliefs about other actors' beliefs and levels of sophistication. However, we do not predict that social skills are directly related to the levels of reasoning in the beauty contest game (i.e., level-K). Rather, we hypothesize that social skills are positively associated with successful strategic decision-making in the beauty contest game (please keep in mind that very high levels of strategic reasoning, as indicated by very low numbers in the beauty contest, do not necessarily mean that individuals are successful in the game).

## 2. Results

We first report the general distribution of guessed numbers in the beauty contest game and their correlation with all other measures, and then we turn to the analysis of depth of reasoning and its predictors. Finally, we report whether the likelihood of success in strategic decision-making can be predicted using the different subscales of the AQ.

First, we found that the average number in the beauty contest game with $N = 188$ was $\overline{x} = 33.06$ (SD = 19.79). The distribution is depicted in Figure 1.

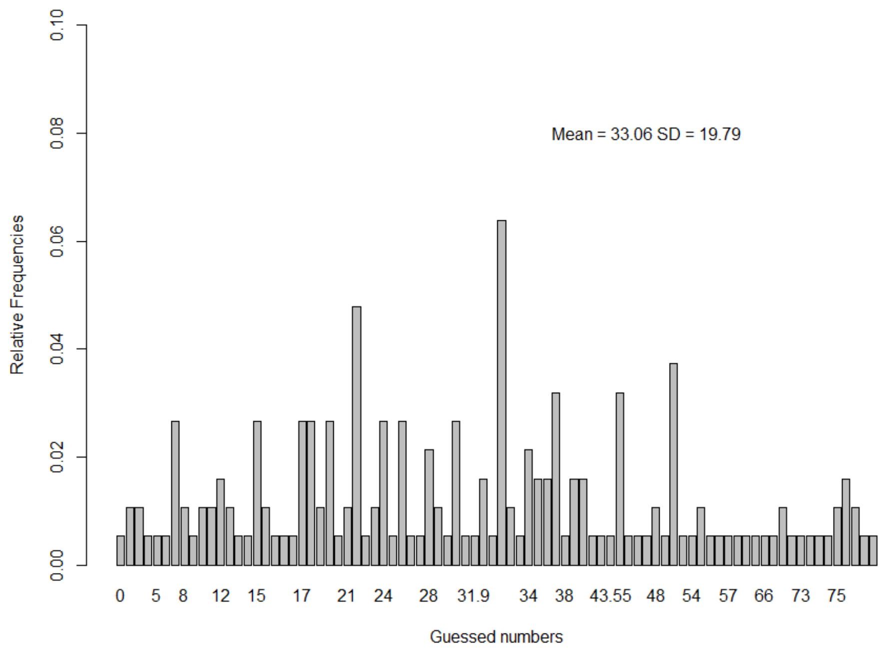


**Figure 1.** Distribution of guessed numbers.

As a second step in the analysis, we calculated correlation coefficients between all measures. In line with previous research (Baron-Cohen [5], Hoekstra et al. [27]), we found significant correlations between the AQ score and gender (women = 1, men = 0), $r = -0.16$, $p = 0.03$ and the AQ score and self-ascribed math skill ($r = -0.24$, $p = 0.001$), indicating that participants high on AQ rated their own math skills as superior to their fellow students. Furthermore, the correlation between gender and self-ascribed math skill ($r = 0.2$, $p = 0.008$) indicated that males assumed to hold higher math skills than females, and women scored higher on imagination than males ($r = 0.45$, $p < 0.001$). Finally, we found significant correlations between some of the subscales of the AQ. The inter-correlations of all measures are depicted in Table 1.

**Table 1.** Correlations of dependent variables.

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Chosen Number (1) | 1.00 | | | | | | | | |
| Math skill (2) | 0.06 | 1.00 | | | | | | | |
| AQ score (3) | 0.04 | −0.24 *** | 1.00 | | | | | | |
| Social skill (4) | −0.10 | 0.13 * | −0.72 *** | 1.00 | | | | | |
| Attention switching (5) | 0.02 | 0.11 | −0.50 *** | 0.39 *** | 1.00 | | | | |
| Attention to detail (6) | −0.02 | 0.14 * | −0.44 *** | 0.23 *** | 0.01 | 1.00 | | | |
| Communication (7) | −0.07 | 0.11 | −0.61 *** | 0.37 *** | 0.26 *** | 0.04 | 1.00 | | |
| Imagination (8) | −0.11 | 0.17 ** | −0.51 *** | 0.33 *** | 0.10 | −0.07 | 0.42 *** | 1.00 | |
| Gender (1 = female) (9) | 0.09 | 0.20 *** | −0.16 ** | 0.00 | −0.06 | −0.09 | 0.05 | 0.45 *** | 1.00 |

Note: * $p \leq 0.1$, ** $p \leq 0.05$, *** $p \leq 0.01$.

## 2.1. Analysis of Level-K Reasoning and AQ Measures

To identify each participant's depth of reasoning, we computed how many iterated steps of reasoning were carried out. In line with Kocher and Sutter [28], denoting each player's $i$ choice $x_i$, the depth of reasoning of player $i$ is defined as $L$ that solves $x_i = q^{L \times m}$, with $q = 2/3$. Since we played a one-shot beauty contest game, we set $m = 50$ as has been done in other beauty contest games with an interval [0; 100] (Bosch-Doménech [2], Ho and Camerer [7], Kocher and Sutter [28], Kocher and Sutter [29]). The resulting continuous values of $L$ were grouped into discrete categories ($L = 0$, 1, 1.5, 2, 2.5, ... 5) by defining the neighborhood intervals for chosen numbers with boundaries $[q^{d + 1/4 \times \mathrm{m}}, q^{d - 1/4 \times \mathrm{m}}]$. Participants who picked numbers that were greater than 50, $x_i > m$, were grouped into a single category with $L < 0$ and all values below $x_i < 7$ were also grouped into the highest level-K. According to this procedure, for example, participants grouped into $L = 1$ (referred to as L1 players), picked a number within the interval [30; 37]. The relative frequencies of the depth of reasoning of participants, neighboring intervals, and interim intervals are presented in Figure 2.

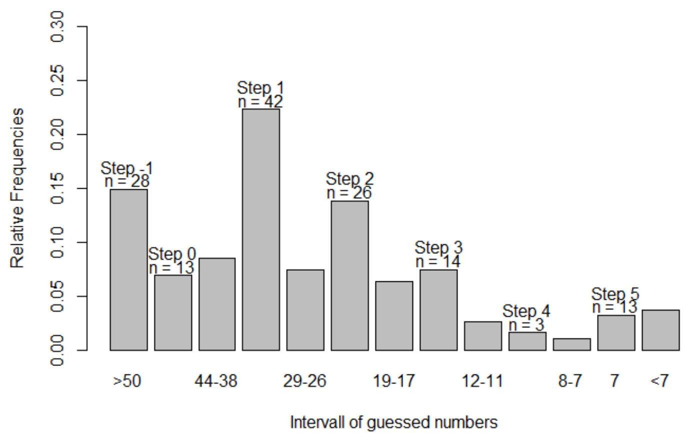


**Figure 2.** Relative and absolute frequencies of choices according to the interval classification. Depicting steps of reasoning, intervals, and interim intervals.

The intermediate intervals were then omitted in the subsequent analyses, since numbers could not be captured by the model (Nagel [6]). We were able to classify 73.9% of the sample, which reduced the sample size to $N = 139$. We then analyzed the results for the AQ score and the three subscales, which yielded internal consistency (Cronbach's alpha > 6).

We then examined the data using scatterplot with a smoother (Loess, a nonparametric, graphical tool for depicting relationships between variables; Jacoby [30]) for the AQ score and the three subscales which yielded internal consistency (alpha > 6) (see Figure 3).

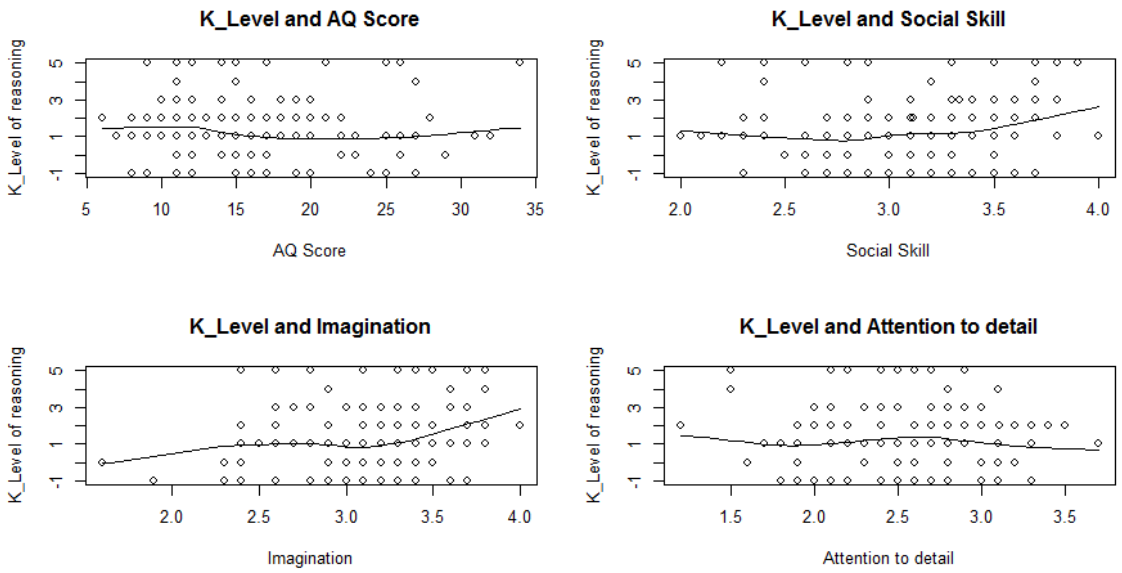


**Figure 3.** Scatterplots with Loess depicting level-K of reasoning as a function of AQ, social skill, imagination, and attention to detail.

We ran a regression analysis to examine the relationship between the depth of reasoning (as measured by $L$) with the total AQ score as well as with each of the subscales of the AQ. The data yields a curvilinear relationship for the social skills subscale. We tested this relationship via a linear polynomial regression with a second degree polynomial predictor (quadratic regression). We found that a quadratic regression fit the data significantly better in the case of social skills, $F(1,136) = 4.40$, $p = 0.04$, but not in the case of the AQ score, $F(1,136) = 2.86$, $p = 0.09$, and the other subscales, that is, imagination, $F(1,133) = 1.12$, $p = 0.29$, and attention to detail, $F(1,136) = 0.22$, $p = 0.64$. This finding indicates that participants scoring very low as well as very high on social skills are likely to carry out more steps of strategic reasoning than participants with average social skills. Furthermore, while only a trend, this curvilinear pattern can also be observed with regard to the total AQ scores.

Next, we carried out individual stepwise linear regressions since all predictors were highly correlated. We first entered the respective predictor and then added math skill and gender sequentially (see Table 2). We found that both imagination and social skills were significant predictors of depth of reasoning, even when controlling for math skill and gender. Imagination was linearly related to depth of reasoning, $b = 1.12$, $t\ (126) = 2.9$, $p = 0.005$. By contrast, we again found a curvilinear relationship between depth of reasoning and social skills. Thus, even when controlling for math skills and gender, both low and high social skills were associated with greater depth of reasoning, while medium social skills were associated with less strategic reasoning as indicated by the significant second polynomial term, $b = 1.48$, $t\ (128) = 2.17$, $p = 0.032$, and first order polynomial, $b = -8.58$, $t\ (128) = -2.07$, $p = 0.04$. The resulting estimates for all models are depicted in Table 2.

**Table 2.** Estimates of individual regressions models predicting depth of reasoning controlling for math skill and gender.

| Predictor | Step | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| AQ | −0.018 (0.026) | −0.022 (0.027) | −0.023 (0.026) | −0.026 (0.027) |
| Math | | −0.101 (0.126) | | −0.273 (0.315) |
| 1 if female | | | −0.395 (0.305) | −0.083 (0.129) |
| Constant | 1.625 *** (0.451) | 2.042 *** (0.674) | 1.933 *** (0.504) | 2.195 *** (0.693) |
| Observations | 137 | 132 | 134 | 129 |
| $R^2$ | 0.003 | 0.008 | 0.016 | 0.015 |
| AQ | −0.241 * (0.138) | −0.241 * (0.138) | −0.25 * (0.138) | −0.25 * (0.14) |
| $AQ^2$ | 0.006 * (0.004) | 0.006 (0.004) | 0.006 * (0.004) | 0.006 * (0.004) |
| Math | | −0.106 (0.125) | | −0.091 (0.128) |
| 1 if female | | | −0.348 (0.304) | −0.228 (0.314) |
| Constant | 3.499 *** (1.195) | 3.872 *** (1.317) | 3.773 *** (1.204) | 4.052 (1.326) |
| Observations | 136 | 131 | 133 | 128 |
| $R^2$ | 0.024 | 0.028 | 0.037 | 0.035 |
| Social Skills | 0.346 (0.343) | 0.357 (0.348) | 0.355 (0.345) | 0.364 (0.351) |
| Math | | −0.089 (0.124) | | −0.07 (0.127) |
| 1 if female | | | −0.363 (0.303) | −0.244 (0.314) |
| Constant | 0.249 (1.084) | 0.527 (1.143) | 0.425 (1.1) | 0.58 (1.155) |
| Observations | 137 | 132 | 134 | 129 |
| $R^2$ | 0.007 | 0.011 | 0.018 | 0.016 |
| Social Skills | −8.23 ** (4.103) | −8.547 ** (4.111) | −8.135 ** (4.121) | −8.584 ** (4.141) |
| Social Skills $^2$ | 1.416 ** (0.675) | 1.47 ** (0.677) | 1.402 ** (0.678) | 1.478 ** (0.681) |
| Math | | −0.078 (0.122) | | −0.063 (0.125) |
| 1 if female | | | −0.317 (0.3) | −0.194 (0.311) |
| Constant | 12.952 ** (6.151) | 13.679 ** (6.156) | 12.974 ** (6.167) | 13.78 ** (6.193) |
| Observations | 136 | 131 | 133 | 128 |
| $R^2$ | 0.038 * | 0.045 | 0.045 * | 0.051 |
| Imagination | 0.791 ** (0.36) | 0.898 ** (0.366) | 1.081 *** (0.382) | 1.116 *** (0.387) |
| Math | | −0.132 (0.127) | | −0.1 (0.128) |
| 1 if female | | | −0.679 ** (0.324) | −0.553 * (0.333) |
| Constant | −1.168 (1.144) | −1.052 (1.168) | −1.699 (1.159) | −1.535 (1.198) |
| Observations | 134 | 129 | 131 | 126 |
| $R^2$ | 0.035 ** | 0.048 ** | 0.066 *** | 0.069 ** |
| Attention to Detail | −0.227 (0.33) | −0.229 (0.334) | −0.238 (0.334) | −0.229 (0.34) |
| Math | | −0.073 (0.124) | | −0.051 (0.128) |
| 1 if female | | | −0.389 (0.306) | −0.277 (0.318) |
| Constant | 1.914 ** (0.861) | 2.177 ** (0.925) | 2.158 ** (0.907) | 2.257 ** (0.956) |
| Observations | 137 | 132 | 134 | 129 |
| $R^2$ | 0.003 | 0.007 | 0.014 | 0.011 |

Note: * $p \leq 0.1$, ** $p \leq 0.05$, *** $p \leq 0.01$.

Importantly, however, the statistical analyses so far do not shed light on the question of whether social skills actually increased the likelihood of winning the beauty contest game, since very high levels of strategic reasoning (indicated by very low numbers in the beauty contest game) do not necessarily mean that players are likely to be successful in the game. To illustrate, in the present study, the target number was 33.06 × 2/3 = 22.04. Hence, level-3 or level-4 players had picked a number too low to win the game.

### 2.2. Distance to the Target Number and AQ Scores

To measure success in the beauty contest game, we calculated the absolute difference between the number entered by a participant and the winning number (two-thirds of the mean), thereby following Coricelli and Nagel [18]. We multiplied the absolute difference with −1, so that less distance between target number and picked number results in values close to zero, while large differences result in higher negative numbers. This measure is referred to as strategic IQ (Coricelli and Nagel [18]), with high values meaning a high strategic IQ. Next, we used strategic IQ as dependent variable in the same analytical procedure as used above.

Results showed that strategic IQ was not significantly predicted by the total AQ Score. In line with our hypothesis, however, we found that the social skills subscale of the AQ predicted strategic IQ, $b = 5.23$, $t$ (185) = 1.91, $p = 0.057$. Moreover, imagination predicted strategic IQ with $b = 4.42$, $t$ (181) = 1.63, $p = 0.11$, although this prediction failed to reach significance. This indicates that higher social skills as well as imagination are associated with higher strategic IQ. All regression models and estimates are depicted in Table 3.

**Table 3.** Estimates of individual regression models predicting strategic IQ controlling for math skill and gender.

| Predictor | Step | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Autism Spectrum | −0.212 (0.205) | −0.232 (0.206) | −0.233 (0.209) | −0.238 (0.209) |
| Math | | −1.291 (0.947) | | −1.354 (0.964) |
| 1 if female | | | −0.768 (2.339) | 0.694 (2.323) |
| Constant | −13.01 (3.52) | −8.276 (5.16) | −12.218 (3.995) | −8.355 (5.347) |
| Observations | 185 | 178 | 182 | 175 |
| $R^2$ | 0.006 | 0.0014 | 0.007 | 0.016 |
| Social Skills | 5.234 * (2.735) | 4.95 * (2.711) | 5.333 * (2.756) | 5.099 * (2.732) |
| Math | | −1.247 (0.922) | | −1.345 (0.945) |
| 1 if female | | | −0.313 (2.296) | 1.114 (2.292) |
| Constant | −32.873 *** (8.655) | −27.747 *** (8.725) | −32.986 *** (8.827) | −28.496 *** (8.82) |
| Observations | 185 | 178 | 182 | 175 |
| $R^2$ | 0.019 * | 0.025 * | 0.02 | 0.028 |
| Imagination | 4.422 (2.711) | 4.598 * (2.682) | 5.604 * (3.031) | 4.842 (2.976) |
| Math | | −1.405 (0.953) | | −1.382 (0.967) |
| 1 if female | | | −2.298 (2.6) | −0.491 (2.571) |
| Constant | −30.707 *** (8.662) | −26.52 *** (8.606) | −33.149 *** (9.122) | −27.077 *** (9.143) |
| Observations | 181 | 174 | 178 | 171 |
| $R^2$ | 0.014 | 0.025 | 0.019 | 0.025 |
| Attention to Detail | 1.584 (2.337) | 2.211 (2.301) | 1.777 (2.367) | 2.581 (2.334) |
| Math | | −1.171 (0.931) | | 1.289 (2.32) |
| 1 if female | | | −0.225 (2.325) | −1.296 (0.956) |
| Constant | −20.524 *** (6.116) | −18.146 *** (6.322) | −20.886 *** (6.434) | −19.398 *** (6.497) |
| Observations | 185 | 178 | 182 | 175 |
| $R^2$ | 0.002 | 0.012 | 0.003 | 0.015 |

Note: * $p < 0.1$, *** $p \leq 0.01$.

In sum, the social skills subscale was a marginally significant predictor of successful decision-making in the beauty contest game, indicating that individuals with higher scores in social skills also yielded a higher strategic IQ. In other words, individuals scoring higher in the social skills subscale of the AQ were more successful in the beauty contest game. Furthermore, entering both predictors in one regression and using an ANOVA testing which predictor explains more variance shows a significant effect for social skills, $p = 0.05$, but not for imagination, $p = 0.28$. Taken together, our findings show that higher social skills are associated with a higher likelihood of success in strategic decision-making.

### 2.3. Checking Results for Sophisticated Players with $L \geq 1$

Following the suggestion of a reviewer, we checked if our results are only driven by the difference between $L0$ players and $L \geq 1$ players. Players with $L0$ are qualitatively different from other players in that they are not playing a best response to any belief about their opponent. Therefore, they are not strategically rational in any sense of the word. For this reason we carried out the same analysis as above for players who are considered at least level 1. In addition, we aggregated players with L5 and L4 because of limited cell sizes (L4 with $n$ = 3 and L5 with $n$ = 13). We find a trend of the inverted U function only for social skills (see Figure 4). The plot shows, that participants scoring high on social skills are more frequently in the group of L3, while participants scoring low on social skills are found more frequently in the L4 as well as the L1 group.

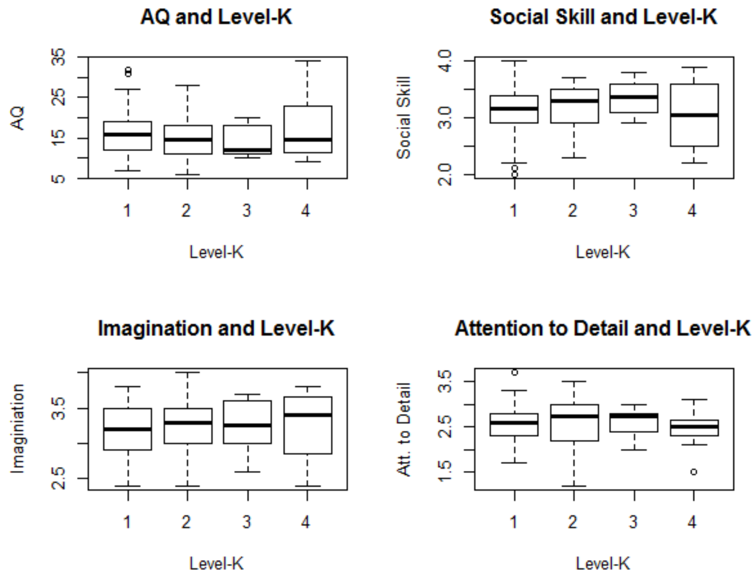


**Figure 4.** Scores as a function of level-K.

To assess if social skills vary significantly between groups of level-K we used ANOVAs. Level-K was entered as the independent variable and AQ, social skill, imagination, and attention to detail were entered as the dependent variable in separate ANOVAs. Although a trend, the difference was not significant for social skill, $F(3,94) = 2.06$, $p = 0.11$. All other ANOVAs yielded $p$s > 0.28. A pairwise comparison for each level-K and social skill with $t$-tests show that L1 differs from L3, $p = 0.029$ and L3 from L4 with $p = 0.035$ (see Table 4).

**Table 4.** Mean social skill for each level-K group (L > 0).

| Level-K | *N* | Mean Social Skill | SD |
|---|---|---|---|
| 1 | 42 | 3.09 | 0.45 |
| 2 | 26 | 3.20 | 0.39 |
| 3 | 14 | 3.40 | 0.28 |
| 4 | 16 | 3.05 | 0.58 |

We then turned to the second dependent variable strategic IQ. First, we plotted the dependent variable Strategic IQ as a function of AQ, social skill, imagination, and attention to detail (see Figure 5).

Then we carried out the same analysis as before (see Table 5). Results were robust for the predictor social skills[1]. Furthermore, attention to detail yielded a marginal significant effect, showing that, when having at least L = 1, higher attention to detail is predictive of a higher strategic IQ.

[1] Interestingly, the predictor gender was found to be a significant predictor of a lower distance to the target number in general, indicating that female participants, when having at least L = 1, pick numbers that are closer to the winning numbers than male participants. However, since the relationship of gender and strategizing was not the focus of the present paper, we refrain from discussing this finding further.

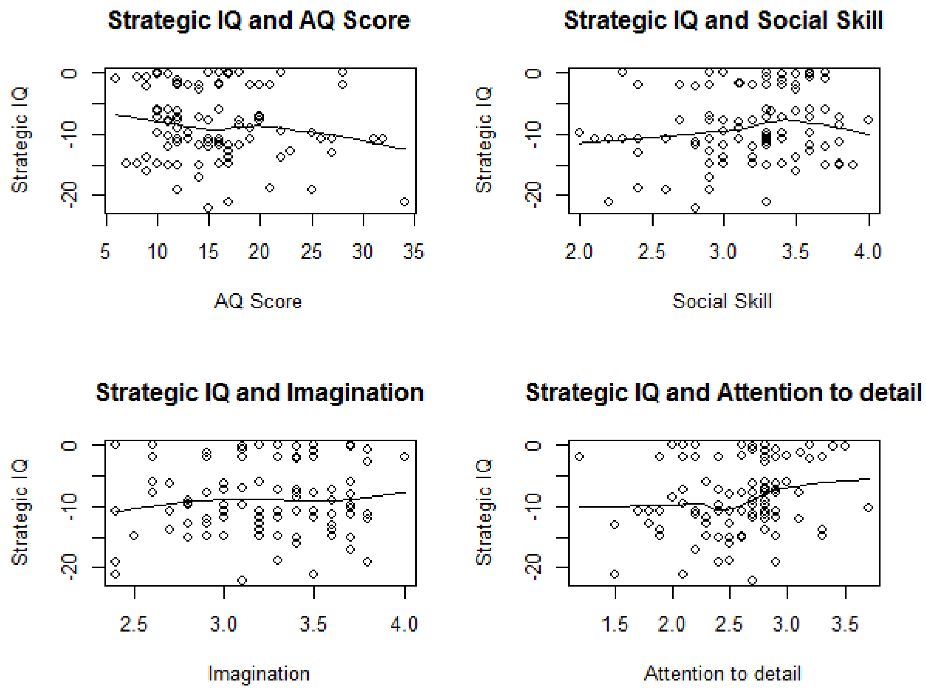


**Figure 5.** Strategic IQ as a function of AQ and subscales (for all L > 0).

**Table 5.** Estimates of individual regression models predicting strategic IQ controlling for math skill and gender for Players L > 0 only.

| Predictor | Step | | | |
|---|---|---|---|---|
| | **1** | **2** | **3** | **4** |
| Autism Spectrum | −0.137 (0.1) | −0.124 (0.104) | −0.14 (0.098) | −0.132 (0.102) |
| Math | | 0.327 (0.487) | | 0.162 (0.481) |
| 1 if female | | | 2.766 ** (1.154) | 2.863 ** (1.193) |
| Constant | −6.72 (1.696) | −7.939 (2.516) | −8.256 (1.777) | −8.94 (2.496) |
| Observations | 96 | 93 | 94 | 91 |
| $R^2$ | 0.019 | 0.024 | 0.076 | 0.083 |
| Social Skills | 2.029 (1.326) | 1.977 (1.345) | 2.375 * (1.302) | 2.365 * (1.321) |
| Math | | 0.391 (0.478) | | 0.213 (0.471) |
| 1 if female | | | 2.973 ** (1.153) | 3.067 ** (1.191) |
| Constant | −15.324 (4.24) | −16.382 (4.469) | −18.117 (4.279) | −18.806 (4.459) |
| Observations | 96 | 93 | 94 | 91 |
| $R^2$ | 0.024 | 0.031 | 0.09 ** | 0.10 ** |
| Imagination | 0.867 (1.539) | 0.697 (1.586) | −0.541 (1.581) | −0.637 (1.613) |
| Math | | 0.427 (0.504) | | 0.302 (0.49) |
| 1 if female | | | 3.375 *** (1.241) | 3.471 *** (1.269) |
| Constant | −11.819 (4.99) | −12.62 (5.099) | −9.241 (4.939) | −9.949 (5.042) |
| Observations | 93 | 90 | 91 | 88 |
| $R^2$ | 0.003 | 0.012 | 0.08 ** | 0.09 ** |
| Attention to Detail | 2.252 * (1.272) | 2.099 (1.301) | 2.563 ** (1.247) | 2.435 * (1.275) |
| Math | | 0.342 (0.479) | | 0.161 (0.472) |
| 1 if female | | | 2.941 ** (1.145) | 3.015 ** (1.184) |
| Constant | −14.672 (3.313) | −15.353 (3.545) | −17.16 (3.365) | −17.386 (3.542) |
| Observations | 96 | 93 | 94 | 91 |
| $R^2$ | 0.03 * | 0.04 | 0.10 ** | 0.10 ** |

Note: * $p < 0.1$, ** $p \leq 0.05$, *** $p \leq 0.01$.

## 3. Discussion

Previous research has found that high levels of strategic reasoning in the beauty contest game are positively associated with working memory capacity (Rydval et al. [9]) and general cognitive ability (Burnham et al. [10]). Other studies showed that skill in forecasting price changes in markets with insiders was correlated with ToM abilities (Bruguier et al. [20]). Furthermore, successful strategizing was found to be related to neural activity in the medial prefrontal cortex, a brain region associated with social cognition and ToM (Coricelli and Nagel [18]) and correctly interpreting emotional expressions of others (Georganas et al. [16]). The current study took this research one step further by examining the link between strategic decision-making and the subscales of the AQ, which is a well-established self-report test to quantify autistic traits in normal adults along a quantitative dimension of individual differences. We hypothesized that social skills (as measured by the AQ) are positively related to success in the beauty contest game. By using a cross-sectional approach and measuring strategic decision-making as well as autistic traits, we were able to directly test this hypothesis.

Our results suggest that the relationship between social skills and the level-K of reasoning in the beauty contest game is captured by a U-function, indicating that individuals with high and low social skills are engaged in high levels-K (level-K of 2 and higher) of reasoning. Importantly, however, higher levels than level 2 were dysfunctional with regard to success in the beauty contest game, since these levels of reasoning were associated with numbers too low for the present sample (to recap, in the present study, the target number was $33.06 \times 2/3 = 22.04$). Calculating the strategic IQ (Coricelli and Nagel [18]), a measure based on the absolute distance between the number chosen and the target number (i.e., a measure of successful strategic decision-making), we found that social skills were positively associated with successful performance in the beauty contest game. These findings support our basic tenet that social skills play a crucial role in successful strategic decision-making.

Importantly, we were able to predict successful strategic decision-making with a brief self-report measure (i.e., the social skills subscale of the AQ), which is completely unrelated to economic contexts. In economic experiments, predictions about behavior are often derived from other economic decisions. For example, social preferences are often estimated using variants of the ring measure (Liebrand and McClintock [31]), a measure which is based on repeated distribution of money; social preferences are then used to predict behavior in public good games as done by van Dijk et al. [32]. In the present study, we were able to predict economic behavior, namely strategic choices, with an ability that is not linked to economic decisions, but social decisions in general, namely social skills. It remains an open question whether successful strategic thinking is a result of higher social skills or whether strategic thinking leads to more successful social interactions resulting in a higher rating of social skills in the self-report.

The results of the present study are challenged by a number of caveats. Most importantly, the present study is correlational and, hence, by definition does not allow for any causal interpretation. While we argued for an effect of social skills on successful strategizing, it is also conceivable that successful strategizing influences social skills. If people are able to strategize well it is most likely that they will be more successful in their social interactions and, as a result, perceive their own social skills as high.

This idea points to another limitation of the current study: the use of self-reports. Self-reports present an efficient way to gather data allowing the analysis of inter-individual differences. However, self-reports could be affected by self-serving bias or social demand. We cannot rule out that ratings were biased, but more importantly, we can show that social skills and imagination that people assume they have are a predictor of their likelihood of strategic success. On the plus side, however, our results suggest that subjective personality questionnaires such as the ones used in personnel selection are able to predict objective measures of successful strategic decision-making. This justifies the use of personality questionnaires in personnel selection. Nevertheless, future studies using behavioral measures as well as peer-ratings of social skills are warranted to replicate our findings.

Another limitation of the present study is that the effects are rather small. While the correlations support the construct validity of AQ, with math and gender being significantly associated with the total AQ score, the correlation between social skills and strategic decision-making was weak, albeit significant. It could be speculated that this is due to the fact that performance in the beauty contest game is influenced by a large number of other variables, for example, cognitive abilities (Burnham et al. [10]) and social-evaluative stress (Leder et al. [33,34]) as well as general character traits (Gill and Prowse [12]).

## 4. Materials and Methods

In the present study $N$ = 188 (female = 55.42%) student participants played the standard version of the beauty contest game as a measure of strategic decision-making and filled out the Autism-Spectrum Quotient (AQ) which is a brief, self-report measure assessing social skills, communication, imagination, attention to detail, and attention switching; finally, they rated their own math skill compared to other university students. Participants were recruited on three different university campuses in Germany. Our minimum sample size was $N$ = 181 as determined by power calculations using the {pwr-package} in R (Champely [35]) aiming for medium sized correlations with $r$ = 0.3 significant at the 0.001 level in order to control for cumulating of Alpha errors due to repeated testing and a power of 0.8.

The AQ (Baron-Cohen et al. [5]) includes questions evaluating both social and non-social domains and examines cognition, behavior, ability, and preferences in a forced-choice format. The 50 items of the AQ are divided into five subscales consisting of 10 items each that assess domains of social-cognitive strengths and difficulties: social skills, communication, imagination, attention to detail, and attention switching. Individuals are instructed to respond to each of the 50 items with one of four responses: "definitely agree", "slightly agree", "slightly disagree", and "definitely disagree". To avoid a response bias, questions in the AQ are counterbalanced, so that half of the "agree" responses and half of the "disagree" responses are scored as an autistic trait. The AQ was designed for adults with average IQ or above, and hence is suitable for use in the student population of the present study. The consistency for the AQ over all items was Cronbach's Alpha = 0.77, the internal consistency and properties of all sub-scales is depicted in Table 6.

**Table 6.** Properties of subscales of the AQ.

| Subscale | Cronbach's-Alpha | Mean | SD | Range | Skew | Kurtosis |
|---|---|---|---|---|---|---|
| Social skill | 0.73 | 3.13 | 0.42 | 2.0 | −0.47 | −0.39 |
| Attention switching | 0.50 | 2.52 | 0.35 | 1.8 | 0.14 | −0.27 |
| Attention to detail | 0.69 | 2.57 | 0.49 | 2.5 | −0.15 | −0.32 |
| Communication | 0.44 | 3.06 | 0.34 | 2.1 | −0.62 | 1.03 |
| Imagination | 0.63 | 3.16 | 0.43 | 2.4 | −0.61 | 0.47 |

To assess math skill we asked participants to rate their own math skill compared to all other students at the university on a scale of 1–6 in school grades (meaning high numbers respond to low skills).

To assess strategic thinking, we employed the standard beauty contest game as used in previous studies, for example, Burnham et al. [10], Coricelli and Nagel [18]. Participants were instructed to choose a number in the interval of [0; 100], which they assume corresponds to two-thirds of the average of all numbers chosen by participants in the study on the respective campus, in order to win 100€. Participants were asked to write down this number.

The study was announced as a survey assessing personality and decision-making. Participants were informed that in the study they could win 100€ depending on their performance in the decision-making task. The material was provided as a paper pencil task and the order of the decision-making task and the questionnaire AQ was randomized. The completion of the survey lasted 10–25 min.

## 5. Conclusions

In conclusion, the research reported in this article contributes to the integration of behavioral economics and social cognition research. It shows that social skills, as assessed by a brief self-report measure, predict successful strategic decision-making.

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**Author Contributions:** Andreas Mojzisch and Leonhard Schilbach conceived and designed the experiments; Andreas Mojzisch and Johannes Leder performed the experiments; Johannes Leder analyzed the data; Johannes Leder, Andreas Mojzisch, and Leonhard Schilbach wrote the paper.

**Conflicts of Interest:** The authors declare no conflict of interest.

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