# Did Social Interactions Shape the Reflective Mind?

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**Abstract**

In recent decades, considerable attention has been paid to the roles played by social factors in the evolution of the human mind. Prominent theorists like David Geary and Keith Stanovich argue that various forms of social interactions have been the main factor behind the evolution of our reflective mind or, as it is called by the dual-process theory, System 2. In this paper I will argue that this account may be challenged by the studies of emotional intelligence (EI) and the neuroimaging studies of strategic thinking. First, only modest correlations would exist between the scores of the EI and IQ tests (a substitute measure for the reflective mind), suggesting that the ability of social / emotional management may not be as closely related to the reflective mind as those theorists would assume. Second, neurological studies found that the brain areas responsible for strategic thinking, which involves the ability of social management, hardly overlap with those activated for reflective thinking. I will conclude that social interactions may have played a less prominent role in the evolution of the reflective mind than currently assumed.

## 1 Introduction

The dual-process theory has drawn considerable attention from psychologists and philosophers in recent decades. It proposes that there are two kinds of information-processing systems working in our mind, characterized by a cluster of properties associated with each system. Responses from the intuitive mind (also called "System 1" or "Type-1 processes") are automatic, quick, and take less mental effort but are prone to error, while responses from the reflective mind (also called "System 2" or "Type-2 processes") take much more mental effort and time (Evans 2008).

This theory explains various experimental results in psychology (see the case of belief bias in 2) and one might wonder about the evolutionary origin of the two kinds of processes or "minds." Dual-process theorists largely agree on the origin of type-1 processes (Evans 2010), which are similar to what evolutionary psychologists call "Darwinian modules" (Tooby & Cosmides 1992) in that Type-1 processes are supposed

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to solve adaptive tasks that our ancestors frequently encountered by responding with fixed outputs to fixed inputs given by the environment.

The evolution of Type-2 processes, or the reflective mind, is a more contentious issue. One hypothesis espoused by some prominent dual-process theorists focuses on the role of social factors (such as Machiavellian thinking) in the evolution of the reflective mind. Those theorists, such as David Geary (2005) and Keith Stanovich (2011), propose that, since social interactions posed unpredictable and changing adaptive problems to us, Type-1 processes fell short of effectively coping with them, and the more time-consuming but reflective processes (Type-2 processes) were required (I will call this approach "the social interaction account of the origin of the reflective mind.").

This paper critically examines this hypothesis and argues that it is in tension with the results from the studies of emotional intelligence (EI) and the neuroimaging studies of strategic thinking. EI is the ability to recognize the emotions of ourselves and those around us and to manage them to cope with various social problems (Mayer et al. 2000). Psychologists have invented a test to estimate one's EI (Mayer et al. 2008*a*,*b*, 2011). The fourth division of the test measures one's emotional management——the ability to cope with emotionally and socially difficult situations. For example, participants are asked to evaluate a person's response to his friend, who changed their mind about going traveling together at the last minute.

One concern from EI studies is about the weak correlations between EI and the reflective mind. If the reflective mind has evolved to cope with complex social/emotional situations, then the ability of reflective thinking and that of social/emotional management would correlate well. However, several studies found only weak correlations between the scores of IQ tests (a substitute measure for the reflective mind) and the estimates of social/emotional management ability, which suggests that this ability may not have a strong connection to our advanced cognitive abilities.

The second problem concerns the neuroimaging studies of strategic thinking. Researchers have studied which regions of the brain are activated when we expect what other people will do in response to our move and decide what to do next accordingly (strategic thinking). If the social interaction account is on the right track, we can predict that the regions responsible for strategic thinking will coincide with those for reflective thinking. This is not the case, however. From these results, I will conclude that social factors may have played a less prominent role in the evolution of the reflective mind than scholars such as Geary and Stanovich have assumed.

The structure of the paper is as follows. In the next section, I will give the overview of the dual-process theory and the social interaction account. Then I will describe the two empirical studies related to the predictions of the account in the third section. First, I illustrate the problem of weak correlations between EI and general intelligence with studies including the one by Louise Attridge (2006). Second, I describe the study by Hampton and others (Hampton et al. 2008) on brain areas responsible for strategic thinking to point out that the results do not properly fit the predictions from the social interaction account.

| (a) | (b) |
|---|---|
| 1. No police dogs are vicious. | 1. No nutritional things are inexpensive. |
| 2. Some highly trained dogs are vicious. | 2. Some vitamin tablets are inexpensive. |
| 3. Therefore, some highly trained dogs are not police dogs. | 3. Therefore, some vitamin tablets are not nutritional. |

Table 1: Syllogisms (a) and (b).

# 2 The Social Interaction Account of the Evolution of the Reflective Mind

In this section I will give a brief overview of what the dual-process theory is and what some of the dual-process theorists say about the origin of the reflective mind.

## 2.1 The Dual Process Theory

The basic tenet of the dual-process theory is that human beings, on many occasions, employ two psychologically distinct processes that are defined by a cluster of (rather phenomenological) characteristics. The first process (the intuitive mind, or System 1) is considered an implicit and unconscious process, while the second process (the reflective mind, or System 2) is considered explicit and conscious.

Dual-process theorists argue that this theory can explain a wide range of psychological phenomena, of which belief bias——the tendency to take an argument with a seemingly true conclusion as valid when it is not——is one example (Evans et al. 1983, Evans 2003). To demonstrate this effect, psychologists have conducted experiments in which participants are asked to evaluate the validity of syllogisms such as the ones in Table 1.

Look at Syllogism (a). It is logically valid: the conclusion must be true if all the premises are true. Syllogism (b) is also valid, though the difference between the two lies in the truth value of the conclusions. The conclusion of Syllogism (a) is true because we can easily think of highly trained, non-police dogs, such as guide dogs. On the other hand, most people would take the conclusion of Syllogism (b) as false because it is a common belief that vitamin tablets are nutritional. If participants only followed the rules of logic, they would evaluate both syllogisms in the same way as the truth value of the conclusion is irrelevant to the validity of a syllogism.

Experiments show that this is not the case. Researchers have found that more people tend to consider syllogisms such as (a) as valid compared to those such as (b). Evans et al. (1983) report that about 90% of subjects see arguments like (a) as valid, while less than 60% think the same of arguments like (b). To explain the discrepancy in responses, Evans proposes that two kinds of information-processing systems act in the participants' minds: one system (the "reflective" system) checks the *validity* of an argument, while the other (the "intuitive" system) uses the *believability* of the conclusion as a cue to the logical validity of an argument. Since syllogism (a) is valid, and its conclusion seems true, both systems give the same response.

Conversely, syllogism (b) is valid, but its conclusion seems false, thus some participants take the argument as valid, while others do not.

This is the dual-process account of a single phenomenon: belief bias. Dual-process theorists have found similar accounts in a wide variety of psychological phenomena, such as probabilistic reasoning, impression formation, and moral judgments (Kahneman & Frederick 2002, Brewer 1988, Haidt 2001). Since those systems have similar pairs of characteristic features, dual-process theorists have integrated those accounts and proposed, as a general account of our mind, the dual-process theory, according to which two kinds of processes (the intuitive and reflective minds) are at play.

Those processes are associated with clusters of properties (see Table 2 of Evans 2008 for a detailed list of properties). Responses from the intuitive mind (Type-1 processes), for example, are described as implicit, unconscious, fast, heuristic, taking low effort, and automatic. The intuitive mind also has the property of giving a fixed response to specific kinds of environmental inputs that are characteristic of the problem domain. In contrast, the reflective mind (Type-2 processes) is described as explicit, conscious, slow, logical, taking high effort, and controlled. With those characteristics, the reflective mind can cope with more complicated problems than those that the intuitive mind handles.

There is one thing to note about interaction between the two kinds of minds. We have seen that one property of the intuitive mind is to be automatic. In other words, one cannot consciously control whether to start type-1 processes in their mind when a relevant stimulus is given. This means that both of the intuitive and reflective minds would likely be at play when we encounter a more complicated problem which may take the reflective mind to respond in an appropriate way. Thus, Geary argues, the reflective mind should somehow *inhibit* the responses from the intuitive mind when giving a final response to the problem. Therefore, inhibition of the outputs from the intuitive mind may well be a property of the reflective mind. This will be important when we infer what supporters of the social interaction account would say about EI, because this function is needed for successful social and emotional management.[1]

## 2.2 The Social Interaction Account of the Evolution of the Reflective Mind

We have examined how the dual-process theory of human mind was developed. If this theory is on the right track, then one might ask how the reflective mind evolved. Some dual-process theorists have attempted to

[1]This overview is intended to convey the original and simplified form of the dual-process theory. Supporters of the theory have substantially revised it since then. Those revisions include: (i) Jonathan Evans and Keith Stanovich, two founders of the theory, revised their argument by which the clusters of properties define the two processes and instead argued that automaticity and the use of working memory are *the* defining features of the two processes, respectively (Evans & Stanovich 2013, but note that Stanovich emphasizes cognitive decoupling ——creating and manipulating the representation of an imaginary situation as separated from that of the real world—— as another defining feature of the Type-2 processing); (ii) Stanovich (2008, 2009, 2011) developed "the tripartite theory of mind" and argued that what we call "the reflective mind" (Type-2 processes) here can actually be divided into "the algorithmic mind" (the abilities to solve well-defined problems efficiently, which can be measured by IQ tests) and "the reflective mind" (motivating us to use the algorithmic mind, which cannot be measured by IQ tests); (iii) finally, some experiments cast doubt on the dual-process framework of logical reasoning and indicated that there may actually be only one kind of process working in our mind (Stephens et al. 2017, 2020). Those revisions and criticisms do not diminish the significance of our analysis on the evolution of the reflective mind because our aim is to show that, *even if* the dual-process theory was on the right track, the social interaction account of the origin of the reflective mind would have problems, and some of the problems could be applied to other social interaction accounts of our mental abilities.

answer this question.[2]

Prominent dual-process theorists (Geary 2005, Stanovich 2011) have proposed that social factors have been underlying the evolution of the reflective mind. Why social factors? They point to the fact that the intuitive and reflective minds are good at solving different kinds of tasks; while the intuitive mind copes well with relatively simple tasks we repeatedly encounter in the stable environment, the tasks faced by the reflective mind arise in the changing environment and are thus more complex and novel. Those tasks are a moving target——more complex and constantly changing as the situation changes. To cope with such a task, one may need to simulate the situation at hand and imagine what would happen if one took a specific action requiring time and mental effort. This is the reason why the reflective mind is called for when the intuitive mind alone cannot act, and those complex tasks can be found in the domain of social interaction.

How do social factors or (as Geary defines them) "social dynamics" pose complex and changing tasks for us? Let us focus on Geary's more detailed account here.[3] By "social dynamics," Geary refers to social interactions in intra-group competition and cooperation and inter-group conflicts, including mate choice (for male as well as female individuals), competition for power and position within a group, and conflicts for resources between groups. One reason why social dynamics make adaptive tasks more complex is that, in social interactions, one needs to monitor and predict the other person's move and act accordingly, while inhibiting the responses from the intuitive mind. We have seen that intuitive responses are tightly related to environmental inputs; however, particularly in social competition, one will be easily exploited if other members can predict how they will react to their move. One could find this kind of exploitation of one's fixed/intuitive/reflexive responses in sports[4] such as basketball and soccer, in which players make a "no-look pass"——passing a ball without looking at the teammate to whom they pass it. This could be highly effective because an opponent player would intuitively think that they will pass the ball to the teammate they are looking at and try to hinder the move.

The same is basically true for cooperation. In collaborative hunting, for example, hunting efficiency will be significantly reduced unless you infer other members' intention by monitoring their actions and coordinate yours accordingly. What these things mean is that you need to suppress fixed and intuitive responses and prioritize those from the reflective mind in order to avoid exploitation and enhance cooperation. For this reason, this type of "motivation to control" plays an important role in Geary and Stanovich's versions of the dual-process framework.

[2]For the evolutionary origin of the intuitive mind, the account of dual-process theorists is relatively straightforward. Prominent theorists (Evans 2010, Stanovich 2004, Geary 2005) all agree that the intuitive mind solves a problem in a particular domain by giving relatively quick, fixed responses to particular cues from the environment. To take an example from belief bias, participants in the experiment merely consider the truth value of the conclusion (a cue and a domain) and judge its validity in an automatic manner (a response). This correspondence between cues and responses, they argue, is the key to understanding the evolutionary origin of the intuitive mind. The response from the intuitive mind does not necessarily yield the logically correct answer in the belief bias. However, if the environment had been stable for a sufficiently long time——so that our ancestors repeatedly encountered the same adaptive tasks, and some behavioral responses were constantly more adaptive——it is likely that the intuitive mind would have eventually evolved to give such adaptive responses when receiving specific stimuli from the environment. In this sense, Type-1 processes are similar to cognitive modules espoused by evolutionary psychologists (Tooby & Cosmides 1992, Amitani 2016).

[3]Evans (2010) does emphasize the fact that the reflective mind is good at novel problems and has evolved primarily during the evolution to human beings, although he does not provide any particular evolutionary scenario——whether focusing on social interactions or not——on its evolution.

[4]Note that this example does not come from Geary.

Secondly, social interactions pose complex tasks by making things highly unpredictable, and this is particularly true of competition. Geary cites the works of behavioral ecologists such as Dawkins & Krebs (1979) to point out that a coevolutionary arms race occurs between organisms with conflicting interests. Two are the ways in which social competition makes things unpredictable. First, in competition, the mere fact that you are usually unable to control your opponent's move is sufficient to makes things unpredictable. Furthermore, opponents have a reason to behave in an unpredictable way because, as mentioned, they would not achieve their goals if their acts could be reliably predicted.

These are the ways in which adaptive tasks tend to become more complicated and unpredictable in the social domain. One could easily see, Geary argues, how they have created considerable selection pressure on mental mechanisms such as the reflective mind. He concisely summarizes this point.

> [S]ocial dynamics generate recurrent and somewhat unpredictable conditions that, in turn, would favor the evolution of brain and cognitive mechanisms that enable the ability to anticipate these conditions, inhibit heuristic-based responses, and generate novel behavioral solutions. . . . [S]everal of the components of fluid intelligence, including the ability to deal with novelty and change, and the corresponding attentional, inhibitory, and working memory competencies are well matched to these conditions. (Geary 2005, p. 300)

In other words, social interactions tend to pose different selection pressures on our mind than the stable environment, and this prompts the evolution of mental mechanisms that solve such problems with more time, more mental effort, inhibition of intuitive responses, and cognitive simulation——in other words, with the reflective mind.

# 3 Problems with the Social Interaction Account

We have seen how some dual-process theorists trace the origin of the reflective mind in social interactions. The fact that social interactions within and between groups characterized the hominid evolution fits some dual-process theorists' belief that the reflective mind is particularly prominent in, if not unique to, human beings; however, this account does not reflect findings concerning social interactions in neighboring fields. In this section, I will evaluate the findings in the study of EI and in the neuroimaging research on what is called "strategic thinking."

## 3.1 Problems from Emotional Intelligence

The first problem of the social interaction account comes from the so-called EI. According to the most prominent model, EI is defined as "the ability to perceive and express emotion, assimilate emotion in thought, understand and reason with emotion, and regulate emotion in the self" (Mayer et al. 2000, p. 396). In other words, EI is a cluster of cognitive and practical abilities concerning emotions. In the model built by Mayer et al. (2000)[5], EI has four branches of abilities, but only the fourth branch of EI, which concerns one's ability to manage one's and others' emotions to deal with a difficult social situation, is relevant to our purpose here.

[5]Three are the main kinds of model on the nature of emotional intelligence (Zeidner et al. 2012): the first one, built by Mayer et al., is called "the ability model," which assumes that emotional intelligence is some kind of ability; the second one, the

When MSCEIT (a test invented to measure one's EI) measures this branch of abilities, participants are asked to read the following scenario and answer the question (Attridge 2006, p. 54):

> James started making plans to go travelling with one of his close friends. James thought his friend was committed to their plans, and was completely surprised when his friend mentioned that he had changed his mind at the last minute. How effective would James be in maintaining a good relationship, if he chose to respond in each of the following ways?
>
> Response 1: James felt sad that he would no longer be travelling with his friend but accepted that his friend had to do what was best for him. James made arrangements to make sure they could keep in touch.

a) Very ineffective
b) Somewhat ineffective
c) Neutral
d) Somewhat effective
e) Very effective

From this instruction, one can see that this branch of abilities is similar to what the social interaction account is about. In the case above, participants need to understand what James's friend feels and believes, recognize James's feeling, suppress any intuitive and emotional response (perhaps James might feel angry, but expressing it publicly may harm his friendship), and imagine and evaluate what will happen depending on his action. All those things are particularly important to maintain cooperative relationship with others when facing a difficult situation, to avoid being exploited by others, and so on.

What would the social interaction account say about EI? Since this question may sound too vague, let us make it more specific. Since researchers of EI have been interested in how distinct EI is from other measures of mental abilities such as general intelligence (if, for example, EI was not sufficiently distinct as a psychological measure from general intelligence, it would be of little use), they calculated the correlations between the scores of EI and those of general intelligence and its correlated measures, such as the scores of standardized tests. Then, what would we expect on possible correlations between the scores of EI and of those measures from the social interaction account?

Although Geary and Stanovich pay little attention to this, one can make a prediction. If, as the account claims, coping with the social environment has shaped the reflective mind, then it would be good at handling possible problems in that domain. Therefore, we can expect that those with a high level of social abilities (i.e., those who can get along with other members of the group in a difficult situation and avoid exploitation by others) will have highly developed cognitive abilities as represented by the notion of reflective mind.[6] That is, individual scores of the fourth branch of EI and the scores measuring one's strength of the reflective mind will show a considerable degree of correlations.[7]

"trait" model, suggests that emotional "intelligence" is actually a trait along with other personality traits, such as extroversion and agreeableness. The third one, the mixed model, holds that EI is a mix of abilities and personality traits. Since the ability model of EI is relevant to our purpose, we will only discuss this one hereafter.

[6] Some might consider the connection not as straightforward. I will address this concern in the final section.

[7] One might say that we make an incorrect assumption that all the social tasks involve emotional factors; on the contrary, we can solve at least some of them without any emotional involvement (we thank an anonymous reviewer for bringing our attention to this point). However, we do not make such an assumption. For emotional factors can create enough selection pressures, if many, but not all, social interactions involve them. And indeed it seems that we frequently feel and deal with a variety of emotions in social interactions.

| Measure | | DAT | GCSE (Overall) | GCSE (Math) | GCSE (English) | GCSE (Science) |
|---|---|---|---|---|---|---|
| MSCEIT | ... | | | | | |
| | B4 (Managing) | $0.29^{***}$ | 0.13 | 0.14 | $0.18^{*}$ | 0.091 |

Table 2: Correlations between MSCEIT (the fourth branch and the total) scores and DAT and GCSE scores. Shortened and edited from Attridge 2006, Table 10. Math, English, and Science are mandatory subjects of GCSE. ***: Correlation is significant at the 0.01 level (2-tailed). **: Correlation is significant at the 0.05 level (2-tailed). *: Correlation is significant at the 0.10 level (2-tailed).

### 3.1.1 Problem of Weak Correlations

We have seen a probable prediction from the social interaction account on the correlation between the fourth branch of EI and the reflective mind. Then is EI strongly correlated with the reflective mind? The answer is no; in fact, only weak correlations exist between individual scores of the fourth branch of EI and those measuring one's strength of the reflective mind.

Attridge (2006) compares the scores of EI (along with those of each branch) and the scores of the verbal reasoning part of DAT (Differential Aptitude Test[8]) and GCSE (General Certificate of Secondary Education; academic achievement tests conducted for high-school students in large parts of the United Kingdom) in 160 16–18-year-old high-school students.[9] As you can see in Table 2, the correlations between the fourth branch of EI and the cognitive and academic achievement tests are weak at best, and most correlations between the fourth branch and GCSE tests (overall and individual subjects) are non-significant. Language-related abilities (DAT and GSCE (English)) are significantly correlated with the fourth branch of EI, but one can explain only 3–8% ($0.18^2$ to $0.29^2$) of the individual differences on the scores of those tests by the score of the fourth branch of EI.

Another study directly assesses the correlations between EI and general intelligence. Bastian et al. (2005) measure those between EI (and its branches) and substitute measures for IQ (the Raven Advanced Progressive Matrices[10] and Phonetic Word Association Test[11]) among about 250 undergraduate college students. The correlation coefficients of the "regulation" or "management" branch of EI with the Raven Matrices and Phonetic Word Association Test are 0.19 and 0.26, respectively. Both are statistically significant ($p < 0.01$

[8] In this part of the test, participants are asked to complete analogical relationships between the words. One question is "... is water as eat is to ...." and the choices are "(a) continue ------ drive (b) foot ------ enemy (c) drink ------ food (d) girl ------ industry (e) drink ------ enemy."

[9] One might say that what standardized tests (and IQ tests) measure is not identical to the reflective mind. However, the results of IQ tests and academic achievements are frequently used as substitute measures for the reflective mind. Correlations between general intelligence and the ability to solve heuristics-and-biases problems are well documented by Stanovich & West (2000). IQ and the scores of formal tests of reading, mathematics, and other subjects are highly correlated (correlation coefficients are from 0.4 to 0.7; Mackintosh 2011). Although a couple of tests have recently been invented to purposely measure one's degree of the reflective mind (the Cognitive Reflection Test (Frederick 2005) and the Comprehensive Assessment of Rational Thinking (CART; Stanovich et al. 2016), no study, as far as I am aware, has reported on the correlations between their scores and EI.

[10] In the Raven Progressive Matrices test, a collection of shapes is arranged according to some rules (Domino & Domino 2006). Participants are asked to find the rules and choose the correct shape to fill in the blank with. For example, in a typical question, eight shapes are arranged so that they form a $3 \times 3$ matrix (with the item at the bottom right corner missing) and participants are to fill in the blank from the arrangement of the other eight shapes. In the "Advanced" Matrices, the problem items are considerably more difficult.

[11] In this test, participants are asked to reconstruct correct English words from their phonetic spelling. For example, 'bouquet' is phonetically spelled as "bowkay." Participants are asked to reconstruct the former from the latter.

in both cases), but one can explain only 4–7% ($0.19^2 = 0.0361, 0.26^2 = 0.0676$) of the individual differences on IQ scores by EI. We cannot say exactly how many correlations are expected between those scores from the social interaction account. However, since there are several psychological constructs the correlation coefficients of which with general intelligence are larger than them,[12] the level of correlation observed in those studies is clearly lower than expected if the hypothesis is on the right track.[13]

### 3.1.2 Is EI Well-Founded?

We have argued that the scores of the fourth branch of EI and those of IQ tests are not as sufficiently correlated as may be assumed. Then supporters of the social interaction account may ask whether EI is well-founded as a psychometric measure in the first place: if not, the lack of strong correlations would have little to do with the credibility of their account. We will reply to this question from two perspectives. First, we will discuss EI's reliability and predictive validity. Then we will address methodological problems with scoring criteria.

**EI's Reliability and Predictive Validity** There are several criteria for sound psychological tests, but we will focus on reliability and predictive validity here for lack of space. Reliability typically means that a test measures the same ability consistently across time or different parts of the test. Predictive validity means that the scores of a test are correlated to the indicators of practical importance, such as academic achievements and income.

To assess the reliability of EI, psychologists have used several scales. Mayer et al. (2003) use the "split-half" method, in which researchers split the entire tests into two parts by, say, the question number. For example, the first part only has questions with an odd number and the second part has those with an even number. If the scores of those halves are sufficiently correlated, the entire test is regarded as reliable. Mayer et al. (2003) demonstrate that MSCEIT is highly reliable as a whole in this respect, reporting that the correlation coefficients between the parts are more than .90. They also reported that correlational coefficients among parts of the fourth branch are above .80. However, not all studies suggest that the reliability is as high as this. To take one example, Zeidner et al. (2005) report that the split-half reliability of the fourth branch of EI is .52.[14] Thus EI's reliability, whether it is about the entire test battery or the fourth branch, is by and large acceptable, although the actual values vary from test to test.

Regarding the predictive validity, various studies have shown that the scores of entire tests and the fourth branch predict some indicators of practical significance. Lopes et al. (2003) and Lopes et al. (2004), for example, found that the scores of the fourth branch of EI is positively correlated with indices measuring the quality of interactions with friends reported by participants themselves and their friends. This suggests that the ability of emotional and social management as measured in MSCEIT could predict how good a

[12] Here I cite two examples. Two meta-analyses report that the capacity of working memory, a psychological mechanism behind general intelligence, is correlated with the scores of IQ test from .72 to .80 (Conway et al. 2011). Openness, one of the "big five" personality traits, is correlated with general intelligence at $r = .33$ (DeYoung 2011), which is larger than the correlation coeffiecients between the fourth branch of EI and general intelligence.

[13] A meta-analysis on the correlations between EI and cognitive ability by Joseph & Newman (2010) provides similar results.

[14] Zeidner et al. (2005) also report that another measure of reliability called Cronbach's alpha for the fourth branch is .84-.86, which is above the desirable level.

relationship one builds with their friends. Therefore, although EI is not as well developed as other metrics such as general intelligence, the reliability of EI is acceptable and the scores of EI has some practical implications.

**Scoring Criteria** Another methodological concern for EI involves scoring criteria (Zeidner et al. 2012). So far, we have assumed that there is a correct answer to the questions of emotional management. One might wonder whether this is a reasonable assumption. Suppose that two participants evaluate the effectiveness of James's response differently in the scenario described above (p. 7). How do we know which evaluation is correct?

Theorists of EI have proposed two scoring criteria to judge the correctness of responses: consensus scoring and expert scoring (Mayer et al. 2003). Consensus scoring evaluates one's choice according to public agreement (for instance, the entire population of test takers); To take an example from James's case, if 45% of test takers perceived his reaction as "very effective," then participants choosing this response will get .45 points on this question. On the other hand, expert scoring evaluates one's choice according to the opinions of experts in the field of emotions, including psychologists, psychiatrists, and philosophers. In James's case, if 45% of those experts judged his reaction as "very effective," then participants choosing this response will get .45 points on this question.

Both scoring methods show problems as criteria for judging the correctness of one's response (Zeidner et al. 2012, pp. 59ff.). One problem of consensus scoring is that the public could be wrong about the issues of emotions. Let us consider a folk belief about emotions, by which Britons traditionally believe that a person with a "stiff upper lip," or a person keeping her emotions inside, is good at dealing with emotional problems. A number of psychological studies, however, have revealed that disclosing one's emotions is actually good for maintaining physical and mental health (Zeidner et al. cite Pennebaker 1997). If the public has been wrong about this issue for a long time, then they may also be wrong about the effectiveness of James's response.

Regarding expert scoring, Zeidner et al. note that this method could work in some branch of EI, such as the perception of emotion in one's face; however, when it comes to emotional management, expert scoring has its problems. One is that discerning contextual factors is extremely important to find a correct response to difficult cases. In James's case, the evaluation of his response may depend on factors such as James's and his friend's personalities, cultural and gender norms of behavior, James's and his friend's positions in the status hierarchy, and so on. This means that even experts' opinions may vastly differ on how to deal with his case, depending on the assumptions they make on those contextual factors.

On these grounds, supporters of the social interaction account might object that the lack of strong correlations between the reflective mind and EI does not undermine their account, because EI is not well-founded in its scoring criteria. However, we find this conclusion too hasty for two reasons. First, despite these concerns for scoring criteria, researchers have found that those criteria give the same answer to the same question in most cases, and, as we have just seen, EI's reliability and predictive validity is by and large acceptable. For example, Mayer et al. (2003) and Lopes et al. (2004) both report that correlation coefficients between the scores based on the two criteria is above .90. If either or both of the criteria were strongly biased, we would not see high correlations between them and EI would not have predictive validity in the

quality of friendship, the area highly relevant to what EI is supposed to assess.

Secondly, the charge of biased scoring criteria cuts both ways for the social interaction account. In order to test their hypothesis rigorously, supporters of the account need to be able to assess one's ability of social interaction (perhaps not for now, but sometime in the future). If they agree with Zeidner and his colleagues that the above criteria are biased, then they need to find another way to assess one's ability of social interaction, which could be a difficult task for them. Furthermore, even if they could find a way, a serious problem would remain as *reputation* plays a significant role in our social relations, involving one's judgments of other members' abilities, personalities, behaviors toward others, and the exchange of opinions among group members on them. If the consensus and expert scoring criteria were strongly biased, then we would be unaware of other members' true abilities of social and emotional management. Then our reputation in this domain would not only be utterly unreliable but also hinder the working of natural selection over social handling, as the reputation on emotional management and their actual abilities would go in opposite directions. This means that selection pressure over emotional and social management may be much weaker than the social interaction account assumes.

## 3.2 Problems from Neuroimaging Studies

Another problem with the social interaction account comes from neuroimaging studies of strategic thinking. As neuroscience has made remarkable progress in recent years, it has discovered neural correlates of various human cognitive and emotional activities, and the reflective mind and social abilities are no exceptions. Researchers in this field have carried out neuroimaging experiments to find brain regions activated by Type-2 processes and social abilities.

What would supporters of the social interaction account predict about those experiments? Although, again, Geary and Stanovich say little or nothing about this matter, we can imagine what their argument would be. If coping with the social environment has shaped our reflective mind, then there would be considerable overlap between the brain regions activated by the reflective mind and being engaged in social management——in particular mindreading, planning behavioral strategies according to it, and inhibiting intuitive responses——because both use a similar set of mental and cognitive abilities. If, on the other hand, there was little overlap between those regions, it would cast doubt on the veracity of the account.

**Neuroimaging Studies of the Reflective Mind** Evans & Stanovich (2013) cite several neuroimaging studies on Type-2 processes,[15] which reveal that participants activate different brain regions depending on whether the intuitive mind or the reflective mind is employed in their reasoning processes.

Goel & Dolan (2003) provide a good example. Their objective is to find brain activity related to belief bias. In their experiments, patterns of brain activation were measured with functional magnetic resonance imaging (fMRI) when participants were engaged in deductive reasoning under three belief conditions——neutral, facilitatory, and inhibitory, which differ according to whether or not the truth value of the conclusion coincide with the validity of the syllogism in question. In the facilitatory condition, for example, a logically valid syllogism has a true conclusion, and an invalid syllogism has a false conclusion. In contrast, in the

[15]See p. 233 of Evans & Stanovich (2013) for a list of the cited studies.

| | | Employer | |
|---|---|---|---|
| | | not inspect | inspect |
| Employee | work | (0¢, 100¢) | (50¢, 0¢) |
| | shirk | (50¢, 0¢) | (0¢, 25¢) |

Table 3: A payoff matrix of the inspection game. Each cell has payoffs for the employee (left) and the employer (right). Source: Hampton et al. 2008.

inhibitory condition, the truth value of a syllogism's conclusion is reversely correlated to its validity. The experiments involved 14 adult participants.

Although various comparisons were made in the experiments, let us focus on the comparison of the brain regions activated under the inhibitory condition when participants made mistakes and when they did not; in the dual-process framework, this corresponds to when participants employ the intuitive mind and the reflective mind, respectively. What was found is that, when participants had incorrect responses under the inhibitory condition, the ventral medial prefrontal cortex (VMPFC), a region thought to be implicated in affective processing, was activated along with other regions such as the left pole of middle temporal gyrus. Conversely, when they had correct responses, the right inferior and dorsal lateral prefrontal cortices were activated, and the VMPFC was *de*activated. This result matches those from other studies. Most papers cited in Evans & Stanovich (2013) reported that the lateral prefrontal cortex (LPFC) and the anterior cingulate cortex (or the areas spatially containing them) were activated when participants inhibited their intuitive responses and gave more reflective ones.

**Neuroimaging Studies of Social Management** Let us turn to the neuroscientific studies of social management. Our focus is on the so-called strategic games (Hampton et al. 2008, Zhu et al. 2012)——one of the hypothetical settings used in game theory, where more than one player is involved, and the success of one player depends on other players' moves. In those studies, participants repeatedly play the strategic game following some learning strategy.

One example is the inspection game (Hampton et al. 2008), in which participants play either the roles of employers or employees. As the employer's goal is to ensure that the employee works diligently, they inspect the employee from time to time, whereas the employee's goal is to shirk as much as possible, provided that the employer does not detect it. Thus, the choices of the employer are either to inspect the employee or not, while those of the employee are to shirk or work. The payoff matrix is in Table 3. As you see, the employee is better off by shirking unless the employer conducts an inspection. If the employer inspects, the employee cannot shirk. Conversely, the employer would be better off if the employee worked diligently even when not inspected.[16]

The researchers assumed that participants adopt one of the following strategies when they play the game: "reinforcement learning" (RL), to make a move that was most successful in the recent past; "fictitious play"

[16]One might point out that the inspection game may not cover the whole array of human social interactions. I agree. However, this point is not very relevant to our project, because our purpose is to examine the social interaction account, and the inspection game shares several important features with the situations which supporters of the account had in mind when they proposed it: requiring players to read their opponent's mind and suppress their own intuitive and emotional responses, for example. Thus if the inspection game does not bode well for the account, we can still cast doubt on the account itself.

(FP), to predict the opponent's action by considering their past choices; or "influence learning" (IL), to adopt the FP strategy *and* consider the influence of one's own action on the opponent's choice. This means putting oneself in the opponent's shoes and imagining what they will do next given your moves. It is similar to what is needed to successfully manage socially charged situations.

Thirty-two healthy participants were involved in Hampton et al.'s experiment, out of which 16 were scanned while playing the inspection game with other 16 participants, both as employers and employees. The researchers made predictions on participants' behavior from the three models and determined which one fit best. The results showed that participants' choices are best explained by the IL model, suggesting that they followed this strategy. Then the researchers found that the predictions from the IL model are correlated with the activity in three brain regions: the medial orbitofrontal cortex (MOFC), the medial prefrontal cortex (MPFC; encompassing both ventral and dorsal aspects), and the right temporal pole. They also compared the RL and the IL models and found that two regions——the mid to dorsal MPFC and the right temporal pole——show better fit with the predictions from the IL model than the RL model. Likewise, they compared the FP and the IL models and found that the predictions from the models differed most in the activity of the MPFC——particularly, for example, when employees switched their strategy from work to shirk.

**Comparison Between the Two Kinds of Studies** Let us compare the results of the neuroimaging studies of the reflective mind and social intelligence. We have seen that there is reason to believe that the social interaction account would predict a significant overlap between the brain regions activated by the reflective mind and social intelligence. Those neuroimaging studies revealed that the results do not fit well with the prediction.

As we have seen, when participants avoid falling prey to belief bias, the right inferior and dorsal lateral prefrontal cortices are activated. The activity of the VMPFC is negatively correlated with the participants' performance on the belief bias test. Other studies of the reflective mind report that the LPFC and the anterior cingulate cortex are activated when we employ the reflective mind. On the other hand, the study of the inspection game shows that the MPFC, MOFC, and the right temporal pole are activated when participants are engaged in considering how their moves affect the opponent's reasoning.

This suggests that there is little overlap between the brain regions activated by the reflective mind and by social intelligence. Furthermore, MPFC, which was activated in the IL strategy, contains the VMPFC, which was activated when participants employed the *intuitive* mind. Of course, those results should not be considered the final verdict on this issue because those studies cover limited aspects of the reflective mind and social intelligence (for example, the inspection game only involves the competitive aspects of social interactions and not the cooperative ones, and the numbers of participants in the experiments are small). However, it shows that the relationship between the reflective mind and social intelligence is not as strong as Geary and others have suggested.[17]

[17]One might think that if the reflective mind activates radically different sets of neural circuits in different cognitive tasks, the lack of neural overlap between the inspection game and the belief bias may pose no problem for the social interaction account, as the reflective mind may have been at play with different neural correlates in both tasks (We thank an anonymous reviewer for bringing our attention to this point). However, as we have seen, the dual process theorists agree that when the reflective mind is employed, several brain regions, such as the lateral prefrontal cortex and anterior cingulate cortex, are activated accross different cognitive tasks (Evans & Stanovich 2013), and those regions are not activated in the inspection game.

# 4 Conclusions

In this paper, we critically evaluated the social interaction account of the evolution of the reflective mind. This account claims that the reflective mind evolved to handle emotionally and socially complex and unpredictable situations. To do so, one needs to monitor others' behavior, change one's action accordingly, suppress one's intuitive responses, and create a novel solution to the problem. The reflective mind, as dual-process theorists have shown, has all those features.

Nonetheless, this scenario presents problems with the studies in the fields of EI and neuroscience. First, empirical studies of EI found that the ability of social and emotional management and the scores of IQ tests (the traditional substitute measure of the reflective mind) are only weakly correlated. Second, neuroimaging studies of the reflective mind and social intelligence showed that the brain regions involved in the two areas of abilities do not significantly overlap, which does not fall in line with the predictions from the social interaction account either.

It must be noted, however, that those results do not show social interactions as completely irrelevant to the evolution of the reflective mind. After all, the scores of EI and IQ tests *are* correlated, albeit weakly. Neuroimaging studies described above only cover limited aspects of the reflective mind and social abilities (and the number of the studies surveyed here and that of their participants are both relatively small), and studies of other aspects may find that they employ a similar set of brain regions. In addition, we can weaken the original account so that it appears to be more plausible given the evidence at hand; for example, supporters of the account might say that the origin of the reflective mind *was* social intelligence, but that it experienced selection pressures from sources other than social interactions. In other words, if it is the case that the original and the succeeding selection forces are of different kinds, the social interaction account is still consistent with some of the points discussed so far.

Thus, the arguments in this paper should not be regarded as a final verdict on the social interaction account. Nevertheless, we can say that, given the arguments and evidence gathered, the account, as it has been proposed, still presents considerable issues.

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