Individual Differences in How Much People are Affected by Irrelevant and Misleading Information

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Abstract

People differ in how much they update their beliefs based on new information. According to a recently proposed theory, individual differences in belief updating are, to some extent, determined by neurological differences, i.e., differences in the organization of the brain. The same neurological differences that affect belief updating may also affect handedness. In particular, more mixed-handed people may have a lower threshold for updating beliefs than strongly right-handed people. On the basis of the proposed theory, we hypothesize that mixed-handed software engineers will be more affected by irrelevant and misleading information when providing expert judgments. This hypothesis is tested in five experiments conducted in software engineering contexts. All five experiments supported the hypothesis and suggest that a low threshold for updating beliefs, as measured by degree of mixed-handedness correlates with inaccurate judgment in situations that contain irrelevant or misleading information. On the basis of the results, we argue that software engineering decisions, problem solving and estimation processes should take into account differences in individuals' threshold for updating belief and not be based on the assumption that one "process fits all".

Background

In a recent study of professional software engineers estimating the effort of software development tasks, we found that adding to a software specification information that was clearly irrelevant strongly increased the estimates of the required effort to develop the software (Grimstad and Jørgensen 2006). Similarly, Kemmelmeier (2004) found that increased awareness that certain information was irrelevant did not lessen that information's impact. He summarizes his finding as follows: "*This produced the somewhat ironic pattern that participants told the experimenter which information was useless, but then went on to use this information in their judgments.*"

Misleading information, relevant or not, may have an even stronger unwanted impact on expert judgment (see for example the studies on anchoring (Abdel-Hamid, Sengupta et al. 1993; Mussweiler and Strack 2001).) Unfortunately, the solution may not be as easy as removing or avoiding it. Crasswell (2006) examined the issue of misleading information from a legal perspective and found: "*In practice, though, eliminating misrepresentation often involves more subtle costs. For example, if we require defendants to say less, in order to eliminate statements that might mislead parties, some of those prohibited statements may also convey truthful and useful information, which will be lost if the statements are prohibited.*"

Empirical studies, e.g., (Long and Prat 2002), and common sense, suggest that there are large individual differences with respect to the degree to which irrelevant and misleading information affects performance. Cann and Katz (2005) summarize results from many studies and find that individuals more affected by irrelevant and misleading information have:

- Poorer memory.
- Higher degree of dissociation, defined as the lack of the normal integration of thoughts, feelings, and experiences into the stream of consciousness and memory.
- A higher disposition towards absorption, defined as the disposition for having episodes of total attention that fully engage one's representational resources.
- Higher level of depression.
- Stronger emotional self-focus, measured as greater fear of negative evaluation or higher self-esteem.
- A tendency to be more easily bored, and consequently less willing to sustain focused attention.
- A more external locus of control, e.g., they are more prone to believe that their successes are caused by environmental and situational factors (external reasons) rather than their own control and performance (internal reasons).
- Better imagery vividness, e.g., they are better able to create vivid visualizations of events.

A recent theory proposes that individual differences in the updating of beliefs are caused, to some extent, by neurological, i.e., brain organization-related, differences (Niebauer, Christman et al. 2004; Niebauer and Garvey 2004). This theory also hypothesizes that a higher threshold for updating belief is associated with a higher degree of communication between the left and the right hemispheres of the brain (larger *corpus callosum*) and can be measured by handedness.

Handedness is determined by the distribution of fine motor skill between the left and the right hands. A person is categorized as mixed-handed, relative to a set of task requiring fine motor skills, if he or she does not have one strongly dominating hand. A person is categorized as strong-handed if he or she has a strongly dominant hand for a set of tasks, e.g., always holds the spoon or the pencil in the right hand. A summary of studies leading to and supporting this theory and the relation between belief updating and handedness can be found in (Jasper and Christman 2005).

This paper tests the following **hypothesis** derived from this theory: *Mixed-handed software engineers are more* *affected by irrelevant and misleading information than strong-handed ones.*

This hypothesis is correlational and based on the belief that handedness and affectability are both, to some extent, caused by the same neurological differences. As we will discuss later on, we are not able to test this belief directly and there may be other reasons for observed correlations.

We tested the hypothesis through five experiments where we presented irrelevant and misleading information to software engineers, either software professionals or students, and asked for their judgments. Then, we analysed the connection between handedness and degree of effect from the irrelevant or misleading information. Although our hypothesis may seem to be a natural consequence of the theory, we found only one study relevant for the testing of it, i.e., (Jasper and Christman 2005). That study contained three experiments, not on software engineers, the results of which were mixed. Clearly, there are many factors and processes involved, and many different types of irrelevant and misleading information, i.e., the scope and validity of the theory is far from settled. In this paper, we focus on testing the theory in a software engineering context. Our long-term goal is to understand individual differences in the effect of irrelevant and misleading information sufficiently well to enable people to improve their processes of making decisions and judgments.

The remainder of this paper is organised as follows. Section 2 describes the design and results of the five experiments conducted to test the hypothesis. Section 3 briefly discusses the results and possible implications for software engineering processes. Section 4 concludes and suggests further work.

The Experiments

All participants completed Oldfield's test of handedness (Oldfield 1971) as part of the experiments. Oldfield's test of handedness provides a participant with a handedness value from -1 (perfectly left-handed) to +1 (perfectly right-handed) based on answers on ten questions. In the following analysis we categorize all participants with the value +1 as strong-handers, and all others as mixed-handed. None of the participants in the experiments had the value -1, i.e., the reported results may be due to right-handedness rather than strong-handedness.

The estimates and judgments produced by the respondents vary much and are typically not normally distributed. For this reason, we apply the more outlier robust median value instead of the mean as a measure of the central value. A combination of a high variation and relatively low number of participants, which is the case in several of the reported studies, means that the statistical power is low and not all of the reported differences are statistically significant. In our case, we argue, it is the set of results from five different studies that is our evidence. Replication of similar, even statistically non-significant, results in differently designed studies with different sets of participants is at least, we believe, just as valid evidence as highly significant results from one study. The graphs illustrating the distributions, effect sizes, and more information about the variation of within-group responses, are not included of space limitation reasons.

Study 1: Anchoring Experiment

Participants: 93 computer science students at the University of Oslo.

Study design: The students were divided randomly divided into four groups:

Group A participants were presented with the following two questions: *1) Do you think you will use more than 5 minutes to read and answer your email tomorrow? 2) How much time do you think you will spend on reading and answering email tomorrow?*

Groups B, C and D were asked the same two questions but with different anchoring values, i.e., Group B received the high anchor value *4 hours*, Group B the very high value *10 hours*, and Group C the absurd value of *22 hours*.

Results: Table 1 shows that the mixed-handers were more impacted by the anchors, particularly by the by most absurd anchor (22 hours), i.e., they had lower estimates in Group A and higher estimates in all the other groups. Interestingly, the strong-handers did not seem to be much impacted by the anchors at all. The difference in response between mixed-handers and strong-handers in Group D is particularly interesting. While the mixed-handers seem to have increased the estimate as a reaction the absurd question "*Do you think you will use more than 22 hours to read and answer your mail tomorrow?*", the strong-handers had the opposite reaction. Possibly, the strong-handers have reacted defensively on the attempt to manipulate their judgment and decreased the estimate to compensate for the attempted manipulation.

Table 1: Median Estimated Time

Group	Mixed-handed	Strong-handed
A (5 min)	7,5 min (n=12)	10 min (n=12)
B (4 h)	15 min (n=17)	10 min (n=8)
C (10 h)	15 min (n=13)	10 min (n=8)
D (22 h)	30 min (n=14)	7,5 min (n=8)

We asked all participants about how much they felt they had been impacted by the anchor (on a scale from "not at all" to "very strong"). The strong-handers felt slightly more impacted than the mixed-handers, but only five mixed-handers and four strong-handers felt that the anchor had had much impact ("strong" or "very strong" impact) on the provided estimate.

Study 2: Hindsight Bias

Participants: Forty-four software professionals at a software process improvement seminar.

Study design: The software professionals were divided randomly into two groups.

Group A participants were presented the following text: *A large insurance company had ten software systems that registered customers and products. The company decided three years ago to replace these systems with one large system that should enable better and more efficient customer care. One important benefit would be that data* *about the customer was registered and stored only one place. The plan was to develop the system in two years. After three years (today) the company has abandoned the project and still uses the old systems.*

Group B participants were presented with the following text: *A large insurance company has ten software systems that register customers and products. The company considers replacement of these systems with one large system, that should enable better and more efficient customer care. One important benefit would be that data about the customer is registered and stored only one place. The plan is to develop the new system in two years from today*.

As can be seen, the important difference between Groups A and B is that Group A participants know the negative outcome, while Group B participants are given a description of a project that is about to start. Participants in Groups A and B were then asked to answer the same questions: *Considering what you believe and know about previous software projects, how frequently [in %] do you think this type of project fails in developing a useful system.*

The example of one failed project received by Group A participants should, rationally speaking, be close to irrelevant for assessing the overall frequency of failed projects of this type.

Results: Table 2 shows that the mixed-handers estimated on average twice as high failure rates in the Group A situation (with misleading information) as in the Group B situation. There was no such difference among the strong-handers.. The estimates of the mixed-handers were lower than those of the strong-handers in the situation without irrelevant information (the Group B situation), i.e., the judgmental processes may be different in the "normal" situation, as well as in the irrelevant information situation.

Table 2: Median Estimated Frequency

Group	Mixed-handed	Strong-handed
A	30% (n=11)	20% (n=11)
B	15% (n=11)	20% (n=11)

Later, we replicated this experiment in a context with 34 software programmers participating at a seminar on cost estimation. The results were similar to those of the previous experiment, see Table 3. The main difference was that the strong-handers were affected, too, although not as much as the mixed-handers. Again, the mixed-handers had the lower estimates of the failure rate in the situation without irrelevant information.

Table 3: Median Estimated Frequency

Group	Mixed-handed	Strong-handed
A	42% (n=10)	30% (n=7)
B	15% (n=10)	20% (n=7)

Study 3: Wishful Thinking

Participants: The same 34 software programmers participated as those in the replicated experiment in Study 2.
Study design: The participants were divided randomly into two groups. Group A participants were presented with information that we believed would induce "wishful thinking", i.e., a situation where the wish to use little effort makes the estimator believe that little effort will be used. Group B were presented with a situation that was more neutral with respect to wishful thinking. All participants estimated the effort that they believed their company would need to develop software based on the same requirement specification, i.e., a specification describing an extension to an existing software system for purchasing football match tickets.

The information designed to induce wishful thinking that was presented to Group A participants was as follows:

"*Moss FK [a Norwegian football club] has invited many providers (more than 10) to implement these extensions and will use the providers' performance on this project as important input in the selection of a provider for the development of the new ticketing system (which is a much larger and more important contract). An independent expert will evaluate the quality, effort and time used by each provider of this project. With sufficiently high quality of the delivered extension of the existing ticketing system, the provider that spends least effort and time will have a better chance of being selected as provider for the development of the new ticketing system. Assume that your company wants to be selected as the provider for the new project and that you are the one to complete the extensions (you represent your company). Estimate the work effort you think you MOST LIKELY will use to complete the described extension to the existing ticketing system. The estimate will not be presented to Moss FK and should be the effort you most likely will need.*"

Results: Again, the mixed-handers were more affected by irrelevant information, this time by the wishful thinking inducing information presented to Group A estimators. Similarly to Study 1, the mixed-handers had different (higher) estimates in the situation without misleading information, i.e., in the Group B situation. The results are displayed in Table 4.

Table 4: Median Effort Estimates

Group	Mixed-handers	Strong-handers
A	15 hours (n=10)	20 hours (n=7)
B	42 hours (n=10)	30 hours (n=7)

Study 4: Sequence Impact

Participants: Forty-two computer science students at University of Oslo (different from those in Study 1).
Design: The participants were divided randomly into two groups.

Group A participants were asked to estimate the effort required to develop software based on a reduced version of a software requirement specification. Then, they were presented with additional requirements and asked to update the estimate to cover the full specification. In other words, they first estimated a reduced version of the software and then the complete version.

Group B participants were only asked to estimate the effort required to develop the complete version.

The specified software was similar to software they had developed earlier as part of their university course, i.e., they had previous experience on development of this type of software. The estimation of the reduced version by the Group A participants should be irrelevant for the estimate of the full specification. However, in two previous studies, i.e., (Jørgensen and Carelius 2004) and (Jørgensen 2006), we observed that participants in Group A situations are likely to produce higher estimates than those in Group B situations. This study examines whether the previously observed difference between Group A and Group B participants was due principally to the mixed-handed estimators' responses.

Results: The results in Table 5 support our belief that the difference in estimates of the Group A and B situation was to a large extent caused by the mixed-handers' and not so much the strong-handers' responses. Similarly to the results in Study 3, the mixed-handers had the highest estimates in the situation without manipulative elements, i.e., the Group B situation. If higher estimates are more likely to be more realistic, this result indicates that mixed-handers are more realistic than strong-handers in situations with little irrelevant and misleading information.

Table 5: Median Effort Estimates

Group	Mixed-handers	Strong-handers
A	360 hours (n=11)	180 hours (n=11)
B	240 hours (n=9)	180 hours (n=11)

Study 5: Misleading Information

Participants: The same 44 software professionals as in Study 2.

Design: The participants were randomly divided into two groups.

Group A participants were provided with a fictive example of a successful risk-averse programmer (Linus Torvalds, Linux) and a fictive study from one company in Canada claiming that risk-accepting programmers (defined as those who agreed to the statement "I like to find my own, innovative ways of solving problems.") were less efficient and had code with lower quality than those who were more risk averse. The participants were asked to provide one likely reason for the finding in the Canadian study.

Group B participants were provided with a fictive example of a successful risk-accepting programmer (Bill Gates, Microsoft) and a fictive study from one company in Canada claiming that risk-accepting programmers were more efficient and did not have lower quality of code. The participants were asked to provide one likely reason for the finding in the Canadian study.

When the first part was finished, all participants were asked the following question: *The example and study from Canada clearly do not represent all situations. Which of the statements below do you think is, in general, most correct?*

I believe that the risk-accepting programmers are:

- *a) always better*
- *b) nearly always better*
- *c) most of the time better*
- *d) better in somewhat more than half of the situations*
- *e) better in half of the situations (no difference)*
- *f) worse in somewhat more than half of the situations*
- *g) most of the time worse*
- *h) nearly always worse*
- *i) always worse*

Results: Table 6 shows that both the mixed-handers and the strong-handers were strongly affected by the misleading information, i.e., the Group A participants thought the risk-accepting programmers were better and the Group B participants the opposite. This means that we may have increased the believability and perceived relevance of the information to a level higher than the belief updating threshold of many strong-handers, too. As before, however, the mixed-handers were more affected, e.g., they have slightly higher frequencies of g and h&i in Group A and of c and d in Group B. The difference is, however, not large.

Table 6: Belief in Risk-Accepting Programmers

Group	a&b	c	d	e	f	g	h&i
A (mixed)	0	0	1	0	2	6	2
A (strong)	1	0	0	1	5	4	0
B (strong)	0	6	3	1	1	0	0
B (mixed)	0	7	4	0	0	0	0

When the participants had provided their assessment, we informed them that the example and the Canadian study were invented for the purpose of manipulating their responses. Then, we asked them to update their beliefs, taking into account this information about the misleading information. Table 7 shows the number of adjustment steps made by the participants. Changing an answer from c to e is, for example, an adjustment of 2 steps.

Table 7: Adjustment Steps

Group	0	1	2	3	4
Mixed-handers	7	7	5	2	1
Strong-handers	11	8	0	1	2

Mixed-handers updated their judgments more (although not much more) than the strong-handers, e.g., while eight mixed-handers updated their beliefs with two or more steps, only three strong-handers did the same. One may argue that a stronger willingness to update belief by the mixed-handers was caused by the stronger need to update. However, an analysis of the answers showed that those who updated made similar initial judgments to those who did not update in both Groups A and B, i.e., it was probably not the *need* for updating that drove the actual updating of beliefs. This is, in our opinion, not surprising. The participants have no obvious way of knowing how much they had been affected by the misleading information.

Even after the corrective information was provided, as many as 60% of those in group A and only 23% of those in Group B believed that the risk-accepting programmers did worse in most situations. It is thus evident that the initial misleading information continued to have a strong impact even after the participants had been told that the information was misleading. It seems, consequently, to be difficult to return to an unaffected state of mind.

Discussion

Limitations

Handedness, as measured by Oldfield's test, is likely to be a far from perfect measure of the cognitive phenomenon we want to measure, i.e., the phenomenon termed "threshold for updating beliefs". Indeed, it is possible that handedness and impact from irrelevant information are not related at all, and that the test of handedness we apply measures something else, e.g., that a test of handedness also measure people's level of confidence in which hand they use for various seldom performed tasks, which again may be correlated to belief updating. This imperfection of the handedness measure may have, at least, two different consequences: i) The real connection between "threshold for updating of beliefs" and the effect of irrelevant and misleading information is stronger that measured by handedness, or ii) The underlying cognitive phenomenon indicated by handedness is not "threshold for updating beliefs", but something else, also connected to handedness, e.g., a difference in use of intuition and analysis-based mental processes. If ii) is correct, the observed connection between threshold for updating beliefs and handedness is accidental. This problem is accentuated by the problems of knowing to which degree belief updating actually takes place in the judgmental tasks of our studies. As long as we do not have a good understanding of the cognitive processes involved in updating beliefs, we should be careful about interpreting the results as more than possibly suggesting a correlation between handedness, as measured by Oldfield's test, and susceptibility to bias on some judgmental tasks. More studies are needed.

Our studies are experiments conducted under laboratory conditions. The experiments provide evidence for the presence of relationships, e.g., that mixed-handed software engineers are sometimes more easily affected by irrelevant and misleading information, but are not well suited to show the size of this effect in real-life situations. It is, for example, possible that many organizations somehow avoid unwanted effects by review of the judgments or by well-designed processes. On the other hand, the effects caused by irrelevant and misleading information are unconscious and a good defence may consequently be hard to develop.

The number of subjects in several of the studies is low and the individual study results may not be very robust. However, the observation that five different tasks with different populations gave similar results should, we believe, enable us to have some confidence in the robustness of the results.

Is a Low Threshold for Updating Beliefs Good or Bad?

Our five studies suggest that mixed-handers are more vulnerable to the effects of irrelevant and misleading information. However, our results also suggest that the mixed-handed participants who did not receive irrelevant and misleading information provided judgments different from the strong-handers. They provided, for example, higher (and, considering the typical tendency towards over-optimism, possibly more realistic) effort estimates. This may indicate that the mixed-handers and the strong-handers were affected differently by both the relevant and the irrelevant information. It may, for example, be the case that a lower threshold for updating beliefs also means that relevant information affects judgment more easily.

The observation that mixed-handers sometimes perform better is consistent with a series of studies in several fields, e.g., (Propper, Christman et al. 2005) reports that mixed-handers seem to have better episodic memory and be less subject to false memories. In (Niebauer, Christman et al. 2004), for example, it is reported that mixed-handers were more willing to use scientific evidence and believed in Darwin's theory of evolution instead of creationism more frequently than the strong-handers.

Drake and colleges (Drake 1983; Drake and Bingham 1988) found that the left hemisphere plays the main role in belief persistence, while the right hemisphere (which is believed to be more active in judgmental tasks by people not strongly right-handed) is more important in changing one's belief. He pointed out that we need a certain degree of stability in our beliefs to benefit from our past experience, but that a degree of flexibility (belief updating) is required to benefit from new experiences, i.e., there is a fine balance between being consistent and being flexible. This balance is, we believe, related to finding the optimal threshold for updating beliefs.

In short, our studies do not show that software organizations should avoid strongly mixed-handed software engineers. The results do however provide some evidence that in situations with irrelevant or misleading information, mixed-handers seem to be easier to manipulate.

What Are the Practical Consequences?

Our results suggest that there are large individual differences in how much software engineers are affected by irrelevant and misleading information and that this may be connected to neuropsychological processes that can be measured by tests of handedness. Possible practical consequences our results include the following:

Software engineers asked to offer judgment in situations in which a great deal of irrelevant or misleading information is provided should be selected carefully with respect to threshold for updating belief. Possibly, software engineering specific tests of how much an individual is affected by irrelevant and misleading information in particular contexts should be developed. The software engineering specific tests may benefit from a comparison of scores with scores from tests of handedness. A high correlation between scores of the tests would suggest that the software engineering specific tests are connected to the underlying, presumably rather stable, neuropsychological processes of the individual, while still being specific enough to be good predictors for the performance of particular types of software engineering tasks.

Software engineers who know that they are easily affected, e.g., by previous experience or tests of threshold for updating beliefs, should learn to take precautions. When, for example, a manager with a low threshold for updating beliefs is in the process of hiring a new employee, he or she may benefit from a carefully structured process for evaluating candidates that leaves as little as possible to unconscious, intuition-based processes. This may, of course, be useful for all managers, but a person with a low threshold for updating beliefs should be especially careful.

The high impact of irrelevant and misleading information on some individuals should lead software organizations and researchers to design improved processes, i.e., processes that reduce the unwanted effects of irrelevant and misleading information. One example of a simple, yet effective, improvement is to remove irrelevant information from a text with a black permanent marker (Kemmelmeier 2004). While people following this process were not affected by the so-called dilution effect, i.e., the tendency to regress the judgment towards the midpoint of the scale with the inclusion of irrelevant information, people just marking the relevant text with a highlighter marker were significantly affected by the irrelevant information.

Conclusion and Further Work

There has, as far as we know, been only one previous study that examines the relation between differences in handedness, as a measure of differences in cognitive processes, and the effects of irrelevant and misleading information on the updating of beliefs. That study, i.e., (Jasper and Christman 2005), examined the effect of misleading anchors and was not conclusive about the relation between the effect of anchoring and handedness. All our five studies found that the mixed-handers were affected more by irrelevant and misleading information. This is, in our opinion, the result we should expect to happen in most situations, given the theory of threshold for updating beliefs and the neurological differences between mixed-handers and strong-handers.

Our results support the view that there are stable, neurological patterns that account for important aspects of how much a person, e.g., a software engineer, is affected by irrelevant and misleading information. We plan to design and evaluate processes that prevent unwanted effects of irrelevant and misleading information particularly designed for those with low thresholds for updating beliefs.

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References

Abdel-Hamid, T. K., Sengupta, K. and Ronan, D. (1993). Software project control: An experimental investigation of judgment with fallible information. *IEEE Transactions on Software Engineering. 19(6)*, 603-612.

Cann, D. R. and Katz, A. N. (2005). Habitual acceptance of misinformation: Examination of individual differences and source attributions. *Memory & Cognition. 33(3)*, 405-417.

Craswell, R. (2006). Taking information seriously: Misrepresentation and nondisclosure in contract law and elsewhere. *Virginia Law Review. 92(4)*, 565-632.

Drake, R. A. (1983). Toward a synthesis of some behavioral and physiological antecedents of belief perseverance. *Bulletin of the Psychonomic Society*. *26(4)*, 313-315.

Drake, R. A. and Bingham, B. R. (1988). Cognitive style induced by hemispheric priming: consistent versus inconsistent self-report. *Bulletin of the psychonomic society*. *26(4)*, 83-94.

Grimstad, S. and Jørgensen, M. (2006). The impact of irrelevant information on estimates of software development effort. Accepted for publication in *Journal of Systems and Software*.

Jasper, J. D. and Christman, S. D. (2005). A neuropsychological dimension for anchoring effects. *Journal of Behavioral Decision Making. 18*, 343-369.

Jørgensen, M. (2006). The Effects of the Format of Software Project Bidding Processes. *International Journal of Project Management. 6(24)*, 522-528.

Jørgensen, M. and Carelius, G. 2004. An Empirical Study of Software Project Bidding. *IEEE Transactions on Software Engineering*. *30(12)*, 953-969.

Kemmelmeier, M. (2004). Separating the wheat from the chaff: does discriminating between diagnostic and nondiagnostic information eliminate the dilution effect? *Journal of Behavioral Decision Making. 17(3)*, 231-243.

Long, D. L. and Prat, C. S. (2002). Working memory and Stroop interference: An individual differences investigation. *Memory & Cognition. 30(2)*, 294-301.

Mussweiler, T. and Strack, F. (2001). The semantics of anchoring. *Organizational Behaviour and Human Decision Processes*. *86(2)*, 234-255.

Niebauer, C. L., Christman, S. D., Scott, A. R. and Garvey, K. J. (2004). Interhemispheric interaction and beliefs in our origin: degree of handedness predicts belief in creationism versus evolution. *Laterality*. *9(4)*, 433-447.

Niebauer, C. L. and Garvey, K. J. (2004). Gödel, Escher, and degree of handedness: differences in interhemispheric interaction predict differences in understanding self-reference. *Laterality*. *9(1)*, 19-34.

Oldfield, R. L. (1971). The assessment of handedness: the Edinburgh inventory. *Neuropsychologia*. *9*, 97-113.

Propper, R. E., Christman, S. D. and Phaneuf, K. A. (2005). A mixed-handed advantage in episodic memory: a possible role of interhemispheric interaction. *Memory & Cognition. 33*, 751-757.