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Research Report

Practice makes two hemispheres almost perfect

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Abstract

Some tasks produce a performance advantage for conditions that require the processing of stimuli in two visual fields compared to conditions where single hemifield processing is sufficient. This advantage, however, disappears with practice. Although no definitive evidence yet exists, there are several possible mechanisms that might lead to improved performance of within- compared to across-hemisphere processing with practice. These include a shift from a more demanding, algorithmic strategy to a less demanding memory-retrieval strategy (e.g., [G. Logan, Toward an instance theory of automatisation. Psych. Rev. 95 (1988) 492–527]), as discussed by Weissman and Compton [D.H. Weissman, R.J. Compton, Practice makes a hemisphere perfect: the advantage of interhemispheric recruitment is eliminated with practice. Laterality, 8 (4) (2003) 361–375], and/or a more generalised practice effect [K. Kirsner, C. Speelman, Skill acquisition and repetition priming: one principle, many processes? J. Exp. Psychol., Learn. Mem. Cogn., 22 (1996) 563–575]. Contrary to Weissman and Compton findings, our results suggest that although single-hemisphere performance improves with practice, bi-hemispheric performance also improves substantially. Furthermore, these effects do not appear to be due to a shift in strategy but rather due to a general practice effect.

Theme: Neural basis of behaviour
Topic: Cognition

Keywords: Lateralisation; Bilateral advantage; Practice effect

The two cerebral hemispheres do not work independently of each other. Information is constantly being exchanged between the left and right hemispheres via the corpus callosum (CC). Sperry, in his work with split-brain individuals (e.g., Refs. [35,36]), was one of the first to recognise the importance of hemispheric interaction in normal cognition. Yet, it is only recently that more research has been conducted to better understand hemispheric interactions.

Hemispheric interactions have been shown to be important for the efficient recruitment of limited resources in heavy load situations [3,9,19,22,40]. The distribution of selective attention has also been shown to be modulated by hemispheric interactions (e.g., Ref. [2]). Different patterns of hemispheric interaction appear to take place over the lifespan and their study has enabled a better understanding of developmental (e.g., Refs. [6,7]), as well as ageing processes (e.g., Ref. [33]). It has been suggested that in old age, hemispheric interactions might assist in the better utilisation of decreasing cognitive resources since older adults seem to rely more on the recruitment of resources located in both hemispheres [10].

The callosal transfer associated with hemispheric interaction comes at a cost. The increase in response time associated with interhemispheric transfer (IHT) has been shown to range from 2 ms, when the information to be transferred is relatively simple and the task to be performed has low processing demands, to possibly as much as 45 ms when the information transferred and the task to be performed are cognitively more demanding [1]. Despite

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this potentially significant cost, performance of specific tasks can be better when two hemispheres are forced to interact than when a single hemisphere receives all necessary information and could perform the task alone. A number of studies [3–5,8,9,37,38,40] have shown that this phenomenon is reliable and can be replicated in different modalities (e.g., tactile, auditory). For instance, in a letter-matching task, if two identical letters (e.g., A–A) are briefly presented to a single hemisphere, or one each to a different hemisphere, performance is better in the single-hemisphere condition. When the task requirements are more taxing such as when the two matching letters are written in a different case (A–a) performance is better when each matching letter is presented to a different hemisphere. This phenomenon is usually called the bilateral distribution advantage (BDA) and is used as a measure of interhemispheric interaction (IHI).

A BDA is thought to occur when task demands are high and additional cortical regions need to be recruited to help in processing [8,29,38]. This recruitment happens in both the single-hemisphere and across-hemisphere conditions but the process appears to be, at least initially, more efficient in the bilateral condition. With practice, fewer regions need to be recruited as processing becomes more efficient, and a decrease in BDA (that is, an increase in within-hemisphere advantage) is observed [20]. Weissman and Compton [39] have found that this increased efficiency due to practice was only observable in the single-hemisphere condition, and was highly consistent with a qualitative shift in strategy due to learning [21]. They suggest that, initially, an algorithmic strategy in which letter pairs are compared sequentially, might be used to solve the task, but that with practice a strategy based on direct memory retrieval might be favoured. Based on the assumption that algorithmic solutions involve more processing steps than direct memory retrieval, Weissman and Compton suggest that the decrease in BDA with practice might be due to a decrease in task complexity and consequently an increase in single-hemisphere processing.

In order to better define the effect practice has on within- and across-hemisphere performance, Weissman and Compton reanalysed two studies investigating hemispheric interaction. The first study [40] used a letter-matching task wherein three (or four) letters were presented in a V-shaped display, with two letters presented in one visual hemifield and the third (or the other two) letter(s) in the other hemifield. The task consisted of detecting whether two letters were matching, with matches occurring either within the same hemifield (unilateral condition) or across hemifields (bilateral condition). Participants were tested in two consecutive blocks. As participants practiced physical- and name-identity versions of the letter-matching task, performance improved more in the within-visual-field condition than in the across-visual-field condition for both tasks. This effect eliminated the significant BDA for the name-identity task, and led to an even larger within-visual-field advantage for the physical-identity task. The second study [37] was based on a similar design but involved assessing the effect of interference, using a global–local perception paradigm, on IHI. The global matching letters to be detected were made up of local smaller letters which could either be congruent with the global letter they were part of, or not. A global–local interference index could then be computed for the unilateral and the bilateral conditions by contrasting performance using congruent or incongruent global–local matching letters. In the initial analysis, it was found that interference decreased when targets were divided between the hemispheres. As in the first study [40] this BDA disappeared in the second half of the experiment, with interference decreasing for the unilateral condition but remaining the same for the bilateral condition.

These results are surprising in that if a strategy shift occurs, it should have influenced performance on both the bilateral and unilateral trials. Furthermore, as Weissman and Compton acknowledge but discount, other theories such as differential priming levels in the unilateral and bilateral conditions could also account for this pattern of results. One potential difficulty associated with the reanalysis of these studies is that data have been gathered in a single (though two-block) session and using a relatively small number of trials. It would therefore be interesting to assess how within-hemisphere performance, compared to across-hemisphere performance, behaves over a longer period of time, using multiple sessions/blocks and large numbers of trials. If a shift in strategy is indeed the cause of the disappearance of the BDA, performance in the unilateral trials would be expected to plateau over subsequent sessions. On the other hand, if performance continued to improve, a different explanation is needed, at the least, that a strategy shift and another practice effect act together. Such a combination of learning effects has been demonstrated by Kirsner and Speelman [18]. They found that results obtained by Logan [21] were better explained by a combination of repetition priming and general practice than by repetition priming alone.

It is also possible that, in addition to the improvement in within-hemisphere performance with practice, performance of two hemispheres working together does improve over time, but at a slower pace than that of a single hemisphere and thus could not be observed in the data used by Weissman and Compton, who used a limited number of trials divided into two (study 1) and four (study 2) blocks.

To answer these questions, we reanalysed data from a large study [11] which used a paradigm similar to that used by Weissman et al. [40] but where relevant data were collected over four sessions taking place on separate days, totalling 2304 trials for each of eighty participants.

We would expect that, if the practice effect is best explained by Logan's model [21], responses to first presentations of unique stimuli should be markedly slower than responses to second presentations. This improvement in response speed should rapidly decrease and plateau