

Psichologija praktikai

THE ADVANTAGES AND DISADVANTAGES OF SINGLE CASE AND GROUP STUDY DESIGN IN NEUROPSYCHOLOGY

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In this essay, the advantages and disadvantages of single case and group study research design methodologies are discussed. The arguments supporting one or the other study design are introduced relying on most prominent scientific opinions in the field. The terms of single and double dissociation are introduced. Examples from relevant neuropsychological studies are provided in order to illustrate the use of case and group study methodologies for single and double dissociation. The two study designs are shown to deal with single and double dissociations in their own way and to contribute significantly to the advancement of neuropsychological sciences. It is concluded that the research design method selected should be tailored to deal with the specific problems raised by the nature of the question under research and fit in the realm of the chosen cognitive theory.

Neuropsychology studies brain–behaviour relationships in terms of cognitive trend, with the goal of understanding the normal relationship between cognition and the brain. The most fundamental assumption of brain impairment studies is the assumption of fractionation, i.e. the belief that certain brain lesions produce a selective impairment of cognitive processing components (Caramazza, 1984). There are two methodological approaches – case and group studies – to examining the effects of brain impairment, relying on fractionation assumption. A case study in neuropsychology

is an intensive analysis of an individual or several individuals, using multiple sources of evidence, investigating the phenomenon of a specific brain injury within its real-life context (Baxter and Jack, 2008). In the group study design, many subjects are included on the basis of some objective criteria (e.g., it could be a damage in a certain brain area) and undergo exactly the same procedures with one or a few sources of evidence to test whether they show a similar pattern of performance. In late 1970s–1980s, a discussion was advanced: which research in pathological population

methodology is more reliable – case or group study design? Several scientists were involved in the argument which of the two study designs provides more information about normal psychological functions and the functional organization of cognitive subsystems. In this essay, the positive and negative aspects of both designs will be discussed, relying on most prominent scientific opinions in the field, and several particular studies will be mentioned in order to illustrate the ways of applying case and group study methodologies in neuropsychology.

First, the case study design will be considered. Numerous authors have claimed the case study of brain-damaged subjects to be the most promising neuropsychological technique (Shallice, 1979; Sokol et al., 1991). They have asserted that by examining in depth one or two persons with specific lesions, determining which cognitive functions are affected and which remain intact, inferences about the structural mechanisms of the functions involved could be drawn. This process is known as *single dissociation*. The classical case of single dissociation of frontal functions was done relying on the evidence of injury of Phineas Gage who had a large iron rod driven completely through his head, destroying much of his brain's left frontal lobe. The effects of that injury on his personality and behaviour were reported (Damasio et al., 1994), giving rise to investigations of frontal functions. *Double dissociation* is the demonstration that “the two tasks make different processing demands on two or more functionally dissociable subsystems” (Shallice, 1979). In this way, double dissociation provides an invaluable methodological tool for establishing the subcomponents of complex

skills: if one manipulation affects the first variable and does not the second, and if the other manipulation affects the second variable and does not the first, the observed processes can be identified as distinct from each other. For example, the double dissociation of episodic memory and long-term memory systems was done by using case studies of two types of neuropsychological patients. The first type, H.M. and L.P., were impaired on long-term memory. The second type, K.F. and K.C., were impaired on episodic memory. H.M. had damaged medial temporal lobes, resulting in a long-term memory deficit, termed amnesia, yet his performance on digit span tasks was preserved (Scoville and Milner, 1957). L.P. was unable to name objects and identify famous faces, but his episodic memory functioned normally (De Renzi et al., 1987). K.F. performed poorly on working memory tasks, but his long-term memory was preserved (Shallice and Warrington, 1970). K.C. was able to learn new facts while his episodic memory was disrupted (Tulving et al., 1988). By analysing in depth the differences in the performance of these two types of cases, neuropsychologists were able to claim long-term memory and episodic memory being separate functions which rely on different mechanisms. Another example of double function dissociation was provided in a study of amnesic patients who showed a spared item recognition but an impaired memory for associations among items (Mayes, 1992). The evidence from this study that amnesic patients show good recognition but poor recall can provide some information about the mechanisms of these two functions in ordinary people with intact brains. The examples presented

in this paragraph have illustrated the use of the single case methodology for single and double memory function dissociation and that the case study approach can have a positive impact on the development of neuropsychology.

Having these advantages in mind, some case study supporters even developed a radical position stating the case study methodology to be the only valid way to conduct research and claiming the group studies using patients to be futile and therefore recommended not to be practiced (Sokol et al., 1991; Caramazza, 1986; Caramazza and McCloskey, 1988). These radicals support their views by arguing that a priori patient classification cannot guarantee the homogeneity of functional lesions responsible for the patients' cognitive impairments. This is because brain damage, even though it may seem to be similar in a group of individuals, may disrupt a cognitive system in a variety of ways. The disparities in performance among brain-damaged patients cannot be dismissed as noise; consequently, the averaged data on a group of patients are inappropriate, and no valid inferences about normal cognitive processes can be made (Caramazza and Badecker, 1989). This argument raises difficulties for group study research supporters, although the issue of disparities among individuals could be overcome by determining certain conditions when planning a group study research. Unlike case-study research, which can, in an extreme case, simply consist of a list of thoroughly studied patients, making minimal assumptions about the relationship among them, the patient-group research method cannot proceed without fulfilling certain condi-

tions of uniformity (Caramazza, 1984). The first requirement is to make the group study well designed: each subject under examination has to be exposed to exactly the same experimental conditions. The second requirement for a group study is to assume that all the subjects tested have one important characteristic – an identical cognitive system or the portion of the cognitive system necessary to accomplish a particular task. Inferences about functions disrupted by brain damage can only be made if it is assumed that the functions were uniform in all individuals prior to the lesion. This assumption receives criticism, since the effects of brain damage are not known a priori, patients' functional deficits may differ within a group, and thus the functional system underlying the performance on a given task may be diverse in group members. A. Caramazza (1984) claims that the two conditions of uniformity are almost impossible to fulfil, therefore case studies remain a superior methodology.

D. Caplan (1988) objects to the views of A. Caramazza, stating that group studies are a valuable source of information and that the above-mentioned problems can be successfully dealt with. The issue of individual variations in performance can be handled by addressing each of the two types of variation sources respectively. The first source of individual variation is caused by variability in the subject's attention; this type of variation is also known as noise. Noise can be dealt with by using suitable statistical techniques. The second type of variation in performance is met when a particular subset of subjects always produces discrepant results for the reasons other than noise. The results of these subsets don't prove the theory being

wrong, and variations may be due to several reasons: the particular subjects may simply have additional deficits interfering with their performance, they may have a different cognitive system, or even if their cognitive system is intact, they may use it in a different way or adopt different strategies to perform a given task. These two types of reasons for individual variations may prove the model not being universal but nonetheless very well suitable for the majority of subjects and therefore important. D. Caplan (1988) provides with an example of how the second type of exceptional performance can provide with information in group studies, and how this information cannot be yielded from case studies. In case studies, if a patient is tested and scores one to two standard deviations below the mean as compared to the healthy population, his or her performance is considered to be normal, and thus subtle minute but important deficits may be left unnoticed. However, in a group study of a population with the same type of lesions, if all the patients score in the range of one to two standard deviations below the mean, they are not considered to have fallen into the normal range. In this way, group studies provide information about a common group quality, even if a certain patient population differs from the controls very little, but still significantly. A comparison of the averages and deviations in the performance of a group of patients with the average levels and of healthy individuals could provide with some valuable information about the illness, cognitive modularity and the neural reorganization in patients (Robertson et al., 1993). This could not be done in case studies. Another advantage of the group study research design is its potential to provide the

same results when retested. Replicability is a valuable quality that cannot be one-hundred-per-cent gained from case studies (Caramazza, 1984), because, firstly, it is rarely possible to find another individual with exactly the same brain lesions, and secondly, even if such person is found, seldom he or she will exhibit exactly the same cognitive functioning deficit. If the second patient does not have all of the symptoms found in the first patient, the study is not replicable and thus it can be assumed as a potential disconfirmation of the hypothesis. Another disadvantage of case studies is that their methodology fails to ascertain whether a subject examined is an outlier or a representative sample of some group (Robertson et al., 1993). Furthermore, a patient with multiple sources of neural damage is likely to have multiple cognitive deficits, many of them being difficult to detect and context-dependent. This problem can be reduced in the group study design in which modularity is tested by including the subjects on the basis of some objective criteria. If the subjects show a certain deficit in the task of interest as a group, then one can be substantially more confident that the observed deficit represents a distinct module and does so across all individuals in a particular group. When significant differences are obtained, it can be assumed that subjects in the group are homogeneous as regards the factor of interest, or at least homogeneous enough for the effect to be observed statistically. The case study methodology cannot provide with information about a patient's cognitive abilities compared to those of others with the same brain disorder; thus, the findings cannot be generalized. One more disadvantage of case studies is that they present no

objective criteria for subject selection, except on the basis of the phenomenon itself, without being sure of its cause (Robertson et al., 1993). This gives little information about the ethology of the symptoms.

According to L. C. Robertson et al. (1993), both group and single-case studies can be used to show a dissociation between the tasks, and when dissociations occur, the group design is superior for several reasons. First, it can demonstrate that significant differences in two functions occur in multiple individuals with particular lesions in a similar way, and this provides more information about the universality of distinct operations. Second, group studies typically offer objective subject inclusion criteria for experimenters who wish to replicate, extend, or refute the results of other studies. Finally, if common physical lesions in a group disrupt one process but not another, then the physical evidence, at the very least, could be used as a reasonable starting point for group inclusion whether or not one is interested only in cognitive theory. In contrast, it is difficult to know what inclusion criteria one should use within the single-case-only approach. However, it is no secret that people vary enormously on their individual performance, and it is because of this variability that more than one subject has to be tested in order to generalize the findings.

Even having taken into account all the above-mentioned disadvantages of the case study methodology, group study research supporters do not propose rejecting single case experiments as radicals have proposed the rejection of group studies. Rather, they advocate that each approach has its own merits, and each methodology should complement the other. Group designs help

discover the cognitive modularity that demonstrate behavioural separability and base the evidence on biological separability, while case studies help gain knowledge by examining the phenomena in depth. Both methodologies contribute to the general goal of neuropsychological data development and gaining biological evidence for the understanding of normal cognition. Which of the two methodologies is more suitable to answer a particular question depends on the field of psychology. Case studies provide valuable information in neurophysiological experiments in which individual's consistency of performance in a particular domain is observed. An example of this type of research could be the one done by M. A. Umiltà and colleagues (2001) who examined the hypothesis that mirror neuron activation could be at the basis of action recognition in two macaque monkeys by investigating in depth neuronal discharge patterns during the execution of hand actions and during the observation of the same actions made by others. In neurophysiological studies, it is assumed that all individuals of the same species share exactly the same neuronal system; therefore, the results from one case examined in depth can be generalized to all members of the species. The group study design is more suitable for chronometric studies in reading, parsing, etc., where the combination of a small magnitude of effects and variations renders a single case analysis an unreliable database. An example of this type of study could be the one made by D. R. Denney and S. G. Lynch (2009) who tested 248 multiple sclerosis patients and 178 controls for differences in processing speed in the Stroop Test. The results showed that the

multiple sclerosis patients tended to have a prolonged processing time by less than two standard deviations as compared to controls and that the differences between the groups increased with age. The group study methodology in cognitive psychology is based upon the assumption that the analysis of group effects will magnify these small, theoretically relevant effects and reduce the variation in performance, which obscures these effects (Caplan, 1988). Thus, case studies are most beneficial in neurophysiological fields and group studies in chronometric research; for the other fields of neuropsychology, it is up to the researcher to decide which methodology fits the nature of the questions and the cognitive theory best. Not only can the two methodologies be used separately, but they

can also be combined in one research. In the beginning, case studies can be used as the first approximation in the development and testing of normal cognition models. If possible, these models should be then followed and retested in group studies on larger samples to investigate the universality of the findings. However, sometimes there is only one or a handful of patients who show a particular deficit or lesion. In such cases, a thorough case study may be the only option, but unless the other means of testing similar functions in neurologically intact or other patient populations are found, the universality of the phenomenon must remain in question, because cases are extremes from both sides of distribution, and it is erroneous to study only extremes to understand the whole distribution.

Table. Advantages and disadvantages of single case and group study designs

	Advantages	Disadvantages
Case study Intensive analysis using multiple sources of evidence from an individual or several individuals, investigating the phenomenon within its real-life context.	Suitable for exceptional cases, e.g., very rare disorders. Examine the phenomena in depth. Provide valuable information about the individual's consistency of performance in a particular domain.	Subtle minute ($< 2\text{std}$) but important deficits may be left unnoticed. Cannot ascertain if a subject is an outlier or a representative sample of some group. Results cannot be 100% replicated or generalized. Multiple sources of neural damage cause multiple cognitive deficits that may be context-dependent and difficult to detect.
Group study Sketchy analysis, using one or several sources of evidence, of many subjects included on the basis of some objective criteria and undergoing exactly the same procedures to test whether they show a similar pattern of performance.	Objective inclusion criteria with the known deficit ethology. Provides information about a common group quality, even if a certain patient population differs from the controls very little ($< 2\text{std}$), but significantly. Results can be replicated and generalized. High statistical power.	The phenomena are examined superficially. A priori patient classification cannot guarantee the homogeneity of functional lesions responsible for the patients' cognitive impairments, because no two people are alike; first of all, individual cognitive systems are different.

To conclude, in this essay the advantages and disadvantages of both case and group study methodologies have been discussed. The arguments in support of both study designs were discussed relying on most prominent scientific opinions in the field. Several particular studies were referred to in order to illustrate the ways of applying case and group study methodologies in neuropsychology. The two study designs contribute significantly to the advancement of neuropsychological sciences and deal with both single and double dissociations, but do that in their

own way. The selected research design methods should be tailored to deal with the specific problems raised by the nature of the investigation and fit in the realm of the chosen cognitive theory. Having considered all the benefits and issues of case and group studies in neuropsychology, it would be reasonable to end with a quote from A. Caramazza and W. Badecker (1989): "There is no right or wrong way to do neuropsychological research". It is up to the investigator to consider all the advantages and disadvantages and be prepared to justify his or her actions.

LITERATURE

Baxter P., Jack S. Qualitative case study methodology: Study design and implementation for novice researchers // *The Qualitative Report*. 2008, vol. 13 (4), p. 544–559.

Caplan D. On the role of group studies in neuropsychological and pathopsychological research // *Cognitive Neuropsychology*. 1988, vol. 5 (5), p. 535–547.

Caramazza A. On drawing inferences about the structure of normal cognitive systems from the analysis of impaired performance: The case for single-patient studies // *Brain and Cognition*. 1986, vol. 5, p. 45–66.

Caramazza A. The logic of neuropsychological research and the problem of patient classification in aphasia // *Brain and Language*. 1984, vol. 21, p. 9–20.

Caramazza A., Badecker W. Patient classification in neuropsychological research // *Brain and Cognition*. 1989, vol. 10, p. 256–295.

Caramazza A., McCloskey M. The case for single-patient studies // *Cognitive Neuropsychology*. 1988, vol. 5 (5), p. 517–528.

Damasio H., Grabowski T., Frank R., Galburda A. M., Damasio A. R. The return of Phineas Gage: Clues about the brain from the skull of a famous patient // *Science*. 1994, vol. 264, p. 1102–1104.

De Renzi E., Liotti M., Nichelli P. Semantic amnesia with preservation of autobiographic memory: A case report // *Cortex*. 1987, vol. 23 (4), p. 575–597.

Denney D. R., Lynch S. G. The impact of multiple sclerosis on patients' performance on the Stroop Test: Processing speed versus interference // *Journal of the International Neuropsychological Society*. 2009, vol. 15, p. 451–458.

Mayes A. R. Automatic memory processes in amnesia: How are they mediated? // *The Neuropsychology of Consciousness* / Ed. by A. D. Milner, M. D. Rugg. London: Academic Press, 1992. P. 235–261.

Robertson L. C., Knight R. T., Rafal R., Shimamura A. P. Cognitive neuropsychology is more than single-case studies // *Journal of Experimental Psychology: Learning, Memory and Cognition*. 1993, vol. 19 (3), p. 710–717.

Scoville W. B., Milner B. Loss of recent memory after bilateral hippocampal lesions // *Journal of Neurology, Neurosurgery and Psychiatry*. 1957, vol. 20 (11), p. 11–21.

Shallice T. Case study approach in neuropsychological research // *Journal of Clinical Neuropsychology*. 1979, vol. 1 (3), p. 183–211.

Shallice T., Warrington E. K. Independent functioning of verbal memory stores: A neuropsychological study // *Quarterly Journal of Experimental Psychology*. 1970, vol. 22 (2), p. 261–273.

Sokol S. M., McCloskey M., Cohen N. J., Aliminosa D. Cognitive representations and processes in arithmetic: Inferences from the performance of brain-damaged subjects // *Journal of Experimental*

Psychology: Learning, Memory, and Cognition. 1991, vol. 17, p. 355–376.

Tulving E., Schacter D. L., McLachlan D. R., Moscovitch M. Priming of semantic autobiographical knowledge: A case study of retrograde amnesia // Brain and Cognition. 1988, vol. 8 (1), p. 3–20.

Umiltà M. A., Kohler E., Gallese V., Fogassi L., Fadiga L., Keysers C., Rizzolatti G. I know what you are doing: A neurophysiological study // Neuron. 2001, vol. 31(1), p. 155–165.

VIENTINIO IR GRUPINIO ATVEJŲ NEUROPSICHOLOGINIŲ TYRIMO PLANŲ PRANAŠUMAI IR TRŪKUMAI

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S a n t r a u k a

Šis apžvalginis straipsnis skirtas vienetinio (*single case study*) ir grupinio (*group study*) atvejų neuropsichologinių tyrimo planų (*design – schemų*) pranašumams ir trūkumams analizuoti. Straipsnyje perteikiami žinomų autorių požiūriai į vienetinio ir grupinio atvejų tyrimų planus, jų pranašumus ir trūkumus, naudojant viengubo atsiejimo (*single dissociation*) ir dvigubo atsiejimo (*double dissociation*) schemas. Pateikiama vieną ar kitą tyrimo planą palaikančių klasikinių ir šiuolaikinių tyrimų pavyzdžių, kaip vienetinio ir grupinio

atvejų tyrimų planai gali būti kiekvienas savitai naudojami viengubo ir dvigubo atsiejimo schemose. Apžvalgoje iliustruojama, kaip abu tyrimo planai, jei naudojami tinkamame kontekste, gali savitai prisidėti prie neuropsichologijos mokslo žinių gausinimo. Apžvalga baigiama rekomendacija tyrėjui, kad, įsigilinus į neuropsichologinių tyrimų planų pranašumus ir trūkumus, reikėtų rinktis tokią tyrimo plano kombinaciją, kuri derėtų su tyrėjo pažiūras atitinkančia kognityvia teorija ir būtų tinkamiausia atsakyti į planuojamo tyrimo klausimą.

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