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Commentary

Is a Science of the Mind Even Possible? Reply to Logie (2018)

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We are pleased to have an opportunity to comment on the thoughtful and provocative article by Robert Logie entitled "Human Cognition: Common Principles and Individual Variation" (Logie, 2018). We found ourselves in strong agreement with most of the article, which could provide relatively little opportunity for a commentary. However, as the title of our reply indicates, Logie's piece could leave the impression that, in fact, a science of human cognition is simply not possible. We are of the opinion that a science of human cognition is, in fact, possible but difficult and demanding of time and other scarce resources to do well. In this commentary we will address both areas in which we agree with the arguments made by Logie, but also ways in which potential methodological solutions to this dilemma exist. Our proposed solutions draw from recent attempts to evaluate performance at the process rather than task level, as well as an approach which combined the study of individual differences with experimental manipulations.

Historically, the experimental tradition of psychology has followed this paradigm: Researchers would adopt a task that seemed to model an issue in which they were interested, manipulate some variable relevant to the task (assumed to reflect some common aspect of human cognition), test a handful of (typically college student) volunteers in a psychology department lab, and report their results as if the task was a perfect reflection of the issue in which they were interested. The data-driven conclusions also generally assume, at least implicitly, that the results generalized to the entire human population, and that the task reflected some aspect of human cognition that is common across different human endeavors. However, history has shown that this method of accumulating knowledge about psychological principles comes with serious limitations. The first limitation which Logie addresses is task design and the performance of an individual versus the aggregate data within a set of task parameters.

Let us use as an example a research topic we have shared with Dr. Logie over the years: short-term memory. We argue that research on this problem can be traced back to the ideas of Donald O. Hebb (1949), namely that there are two types of memory traces: temporary reverberatory traces resulting from events that occur in proximity to one another, and consolidated structural traces that occur if the reverberatory traces are allowed to consolidate in the absence of interference and interruption (Engle & Oransky, 1999). These short-term traces became a model for short-term memory in models and theories of memory, including the seminal work by Atkinson and Shiffrin (1968). Studies on short-term memory quickly settled on a very few methods thought to reflect the concept, but the one used most commonly was to present people with a short list of verbal items, typically from a small item pool such as digits or a small set of letters or words, and have subjects attempt to recall them—generally in order. There was little concern about whether this procedure reflected anything common about human cognition in the real world and, as Logie writes, it gave little regard about whether people might differ in how they would perform such tasks or whether a given person performed the task in the same manner from testing to testing. In fact, Crowder (1982), argued in a paper entitled "The Demise of Short-Term Memory" that the fact that performance on this type of task did not correlate with performance on tasks thought to depend on short-term memory argued against the idea that short-term memory was distinctly different from other types of memory.

As a result, hundreds of studies were performed on variables that were important to the ordered recall of short lists of digits, letters, or words. Replicable findings showed that people doing

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these tasks *tend* to think of those items the way they would sound if spoken—what was often referred to as phonological or articulatory coding (Baddeley & Hitch, 1974). Conrad (1964), for example, showed that most adults, at least some of the time, tend to code even visually presented information in phonological or articulatory format when doing such tasks. It is clear that children are less likely to do this type of coding than adults, and the tendency to do phonological coding may play an important role in learning to read. What is not clear is where in the real world such coding is important or whether this is a strategy of choice anywhere other than in such experiments. There is a lack of evidence that ordered recall of short lists of digits, letters, or words reflects a type of cognition performed in the world outside of laboratories in university psychology departments and with the highly selected group of humans who happen to find themselves doing psychology experiments in those laboratories. That is, what are such tasks designed to model in the world in which those subjects find themselves when they leave the lab? Logie's excellent analysis of models of memory for serial order is eerily reminiscent of the complaints of Lashley (1951) over 70 years ago about serial order in behavior. The tasks that are used to study this problem just do not seem to capture the complexity of serial order in the real world, and therefore models based on those tasks seem to have little utility in understanding how we are able to make use of serial order in the world.

In addition to making assumptions about the relationship between task design and real-world behavior, experimental psychology tends to aggregate data across subjects, which gives the impression that all individual subjects behave similarly to the way the grouped data would suggest. This often hides not just individual variation on task performance, but can totally mislead about the way every individual behaves under various task conditions. For example, suppose we do a study in which subjects are asked to identify a concept. The stimuli presented to the subject are squares, circles, or triangles presented in groups of 2, 3, or 4 and in either red, green, or blue. The subject is asked to press one key when the stimulus reflects the concept the experimenter is thinking of but a different key if the stimulus is not the one being thought of by the experimenter. Subjects receive a reward when they press the correct key and no reward when they make an error. Suppose the experimenter is thinking of 2 red circles as the concept to be identified. If we look at the trials to achieve perfect performance and aggregate across subjects we will see a traditional learning curve approaching perfect performance. This suggests that learning is a slow, gradual, and incremental process. However, if we line all subjects up at the trial on which they make their last error and all subsequent trials are correct and then aggregate the data, we will often see that responding was at chance until the trial of last error and then responding was perfect. This suggests that learning is all-or-none, sudden, and insightful. In other words, how we aggregate data across subjects is terribly important in the nature of the cognition we assume in the heads of our individual subjects (Restle, 1965).

A second difficulty Logie (2018) describes is that any given experiment might only reveal those aspects of cognition reflecting performance above floor and below ceiling. He posits that this might be a problem with studies of individual differences and he is right about that if only one study is done. However, it is often the case that a program of work will systematically conduct studies to eliminate these limits on understanding. Permit us to use our own work as an example of both the problems and the potential solution to this conundrum. We had shown repeatedly that working memory capacity as measured by various verbal tasks was highly related to reading comprehension (e.g., Turner & Engle, 1989). However, an alternative hypothesis was that this relationship was not about structural limits on working memory capacity but due to the fact that both tasks were verbal so it may reflect verbal ability. Engle, Nations, and Cantor (1990) tested this hypothesis by varying the frequency of the words used to assess working memory capacity. The argument was that if the alternative hypothesis was correct, then the relationship between working memory capacity and reading comprehension should be significant when low frequency words were used in testing but not when very high frequency words were used. The results showed a significant relationship for both sets of words. The study functionally assessed the relationship at different points on the performance curve and still found the relationship.

Another example that makes Logie's point is a set of studies by Rosen and Engle (1997). This paper reports several studies measuring verbal fluency reflected in the number of items from a category such as animals that can be recalled in a 10 min period. We found a strong relationship between the number of animals recalled and the individual subject's working memory capacity as measured by complex span tasks. We did this study with an extreme group design in which we tested people from the upper and lower quartile on a previous assessment using the complex span tasks. What we had not taken into consideration was that working memory capacity is highly related to fluid intelligence, the ability to solve novel problems. Thus, our high spans were also likely high fluid intelligence individuals. In subsequent studies including Shipstead, Harrison, and Engle (2016), we assessed both constructs using multiple tasks for each construct and a full range of abilities. Thus, we could partial out each of the two abilities separately. When we did that, we found that the relationship to verbal fluency was *not* with working memory capacity but was with fluid intelligence. This makes Logie's point that careful and systematic work must be done to delineate the nature of relationships and the variables that are actually driving performance.

Individual Differences in Strategy Use and Benefits of the Differential Perspective

Another excellent point made by Logie (2018) is the need to aggregate subjects using the same strategies and the consequent problems that can occur when data from subjects using different strategies are aggregated (see Newell, 1973). A wonderful example of this is the elegant work by Earl Hunt and his colleagues (Hunt & MacLeod, 1978; MacLeod, Hunt & Mathews, 1978). In a study on verbal abilities, they used a task developed by Clark and Chase (1972) in which subjects were shown an affirmative phrase such as *plus above star* or a negative (e.g., *star is not above plus)*. Subjects were then shown a picture of a star and plus sign either in juxtaposition or not corresponding

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to the phrase and were then asked to indicate *true* or *false* as to whether the picture corresponded to the phrase. By manipulating affirmative or negative and true or false, and by measuring the time to perform various stages of the task, multiple studies suggested that subjects held the phrase in a linguistic form and when the picture was shown they compared the two phrases (Carpenter & Just, 1975). The evidence was that negatives took longer than affirmatives and false took longer than true which meant that response time was a linear increasing function of these values. However, MacLeod et al. (1978) noticed that subjects did not all seem to perform as the model suggested. They found that most of their subjects did perform as the model suggested; however, a substantial number of subjects performed differently. Their strategy was to turn the phrase into a picture and, when the picture test was presented, to compare the two images. This meant that their verification times were overall faster and of a very different pattern from the subjects that fit the model well. In other words, the two groups of subjects were using two completely different strategies and their data should not have been aggregated. The group that used the visual code were shown to be equivalent to the verbal group in verbal abilities but did show higher spatial abilities. We would argue here that studies that focus on both individual differences as well as differences between groups given different treatments are more likely to observe the findings obtained by MacLeod et al. (1978). In fact, it was that group's focus on individual differences that led to the discovery.

This work also bring us back to Logie's excellent point that variability in performance will only be found when subjects perform above floor and below ceiling, which he claims is particularly a problem with studies of individual differences. However, such studies require substantial variability and exploring the nature of that variability can be the means to discovering interesting differences in the way people perform. The MacLeod et al. (1978) study is a good example of that. Other studies that had used the Clark and Chase task likely had the different groups of subjects, but the ones who used a visual code to perform the task would have been hidden in the larger variance of the data. By looking for differences in variance patterns they were able to identify the groups.

Defining Reliability

Perhaps the strongest point that Logie (2018) makes reflects the difference between how experimental psychologists and differential psychologists think of reliability. In experimental psychology, reliability refers to whether a manipulation leads to an effect that is statistically greater than chance and whether the effect can be replicated by other researchers. This might be akin to how a group of weight scales reflect a known weight in cold conditions versus hot conditions. Differential psychologists generally think about reliability as the extent to which a task reflects similar patterns of performance for a person over repeated testing. This would be akin to the measurement of a known weight over repeated testings on each scale. A combination of the two approaches would be to compare how each scale responds to repeated testing with a known weight under conditions of heat and cold. Let's take the beautiful example from Logie's own work.

There are several phenomena from short-term memory studies that are highly replicable in dozens if not hundreds of experiments reported over the last 30 years or so. These include the phonological similarity effect and the word length effect. Let's focus on the similarity effect (Baddeley, 1966; Conrad & Hull, 1964). Lists of letters or words that are phonologically similar are recalled less well than lists composed of dissimilar sounding items regardless of whether they are presented auditorily or visually. Likewise, short lists of short words are recalled better than short lists of long words regardless of their presentation modality. These are widely replicated findings and, in fact, we replicate them each term as a demonstration in our undergraduate classes. This might suggest that nearly everyone performs this task by converting the shown or spoken items to a speech-based or phonological code and then by rehearsing that code. Logie, Della Sala, Laiacona, Chalmers, and Wynn (1996) conducted an analysis of these tasks at the aggregated group level (as experimental psychologists would do) as well as at the individual level (as differential psychologists would do) for a very large sample. They replicated the effects at the group level but they found that a substantial minority of subjects did not show the effects. Even more important, they found great variability in whether subjects used phonological coding in the tasks from testing to testing.

This is an important finding. If one cannot assume that two of the most highly replicated findings in cognitive psychology can be relied on to occur in all subjects *and* that many subjects vary in their use of this type of coding from test to test, how are we to have confidence in the myriad findings in cognitive psychology that are smaller or more ephemeral? Does this suggest, as the title of our paper states, that a science of the mind is impossible? We think that the answer to that question could be yes, *if* (1) researchers focus on a single task thinking that that task reflects a construct such as short-term memory, (2) researchers focus only on experimental approaches in which data are aggregated across individuals without regard to possible differences in strategy or ability to do the task being performed, and (3) researchers test only people who are convenient such as college subject pools without regard to their similarity to the wider human population. However, we think a more optimistic answer is that, with a slightly modified approach, the answer can be that a science of the mind *is* possible. We suggest here a combination of experimental and differential approaches.

Potential Solutions: Making the Science of the Mind Possible

The Importance of Latent Variable Analyses

First, as we have briefly addressed, one manner in which to avoid the issue of erroneous extrapolation from task performance to theoretical construct is to examine performance at the latent rather than the task level. Latent level analyses allow for the use of multiple tasks to define a construct. As such, the resulting construct reflects variance that is shared across the task set. For example, a factor measuring working memory capacity

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can be made using a series of tasks which vary substantially in their surface characteristics. The idea being that the common property necessary to execute all of these tasks well is shared among these three tasks. Although researchers will sometimes refer to a specific task as reflecting "working memory capacity" due to its inclusion on a factor for that construct, this inference is inadequate. For example, some complex-span measures of working memory capacity show differential predictive validity depending on the ability range of the subjects (Draheim, Harrison, Embretson, & Engle, 2018). Should a task which only discriminates well at the low ability end be used on a relatively homogenous sample of higher ability individuals, any group differences will be muted, further adding to issues regarding tasks which only reveal performance differences when cognition is maximally extended. Alternately, a latent construct which includes measures which discriminate across a wide range of abilities will provide a much more reliable assessment of that psychological construct across a range of abilities. In short, the use of a latent constructs allows for the examination of shared processes across various task structures.

This suggestion echoes a point that is more subtly made by Logie (2018) and that is that understanding cognition requires that we think about cognition at the construct level, not at the level of the individual task. Virtually every task used by psychologists can be performed in myriad ways using myriad strategies. That is, our tasks are multiply determined. Thus, we strongly recommend that multiple tasks be used to reflect each construct studied. In other words, each and every task is multiply determined both across and within subjects and our only hope of understanding cognition at a general level is to study cognition at the construct level. No single task will provide us useful and generalizable information across subjects and across situations.

Maintenance and Disengagement: A Process General Approach of Measuring Cognitive Processes

To borrow a specific example of how latent level analyses can be beneficial in examining processes rather than task specific differences is the theory of maintenance and disengagement proposed by Shipstead, Harrison, and Engle (2016). This theory takes a process-general approach to examining the functions of the central executive. *Maintenance and disengagement theory* proposes that among the primary functions of the central executive are to maintain relevant information (maintenance), and release no-longer relevant information (disengagement). Further, these processes can be isolated and differentiated at the latent level by using complex span measures of working memory capacity and measures of fluid intelligence.

Specifically, Shipstead et al. (2016) suggest that complex span measures of working memory capacity rely heavily on maintenance of information active over the course of a set of trials, while minimally relying on disengagement to the extent that processing information must be identified as not necessary for later retrieval. Fluid intelligence measures, on the other hand, rely heavily on the ability to test hypotheses quickly. In order to do this well, and score well on these measures, individuals must be able to rapidly release old hypotheses as well as avoid re-testing failed hypothesis. Failure to do so results in perseveration which ultimately results in a lower score. Just as the complex span measures of working memory capacity rely primarily on the maintenance of information and minimally on disengagement, fluid intelligence measures rely primarily on disengagement or release of information, and very minimally on the maintenance of information (i.e., holding onto a hypothesis while it is being tested). The degree to which these processes can be dissociated in predicting higher order cognition has also been verified with regard to reading comprehension, vocabulary learning, and prospective memory performance (Martin et al., 2018; Martin, 2018).

Of primary importance to the issues presented by Logie (2018), this perspective takes a process, rather than task or construct approach, preferring to look at the processes of maintenance and disengagement rather than specific mechanisms through which these processes are executed. For example, some individuals may use a rehearsal strategy, while others may use imagery to maintain information. Alternately, some individuals may engage in disengagement by tagging items for non-retrieval, inhibiting a representation, or unbinding an association. The important consideration here is that, at the latent level, these processes are captured equivalently well, regardless of the mechanisms used to achieve the goals of keeping important information easily accessible and reducing the search set by releasing no-longer-relevant information. As such, the maintenance and disengagement theory provides one potential solution to the task versus process question in several ways. First, it makes use of latent level analyses which, in turn, reduce the influence of a single task paradigm. Second, the latent constructs used are highly reliable, as they do not rely on difference scores and are examined at the latent level. Third, the maintenance and disengagement framework allows for inferences about processes independent of the mechanisms used to achieve them. However, more work is needed to identify ways and degrees to which individuals of varying ability may employ these strategies, which in turn requires a return to a hybrid approach of both differential and experimental methods in order to make sound conclusions regarding the processes of cognition that are involved in complex, everyday activities.

Variability and Population Selection

One final issue we would like to revisit regards the populations included in many of our cognitive psychology studies and their variability in performance, or lack thereof. The majority of experimental studies are conducted using a convenience sample of undergraduate students. These students are often participating in exchange for course credit. Even larger-scale studies are often restricted in range as they still primarily consist of a relatively homogenous sample of individuals. These homogenous convenience samples are essentially a highly selected group of people, and it is naïve to think that what we discover from this group represents how the broad range of human adults in the world would perform the tasks we assign them. The use of college students is convenient and is likely a carry-over from a time when rats or other animals were convenient to use, and

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it was assumed that they all were the same except for random variation. We now know that, in fact, they are not all the same (Matzel et al., 2003) and that those differences impact the way tasks are done just as with humans. The use of a homogenous younger adult population makes studies of individual differences in performance exceedingly difficult to extrapolate to outside populations. Moreover, inferences about differences in performance are even more difficult to infer when using extreme group designs that include older adults.

While it is beyond the scope of this commentary to discuss these issues across the lifespan, it would also be inadequate to discuss the issues with task specific effects without also considering population specific effects as well. As mentioned previously, some cognitive tasks differentially discriminate at higher or lower ends of a distribution (Draheim et al., 2018). As such, task selection for the intended population becomes even more critical when studies are being conducted at the task rather than the latent level. In order to make broad inferences regarding individual differences, a wide ranging sample must be included, and preferably evaluated at the latent level, for meaningful inferences to be made. Further, older and younger samples are inherently different in their variability, with younger adult populations frequently represented by a convenience sample reflecting a relatively narrow range of abilities (regardless of where they fall on a distribution), and older adults reflecting a more diverse population.

Conclusion

The fundamental problem with a true science of the mind is that an approach which combines experimental manipulations, latent variable analyses, and a diverse group of subjects is extremely expensive in time and money. Studies which do successfully integrate all of these factors in order to investigate a psychological phenomenon require many months, hundreds of subjects, and subjects who often have to be paid for their time if they can't be convinced to volunteer. We are under no illusions about the difficulty of this approach since that has been our approach for many years (Engle & Kane, 2004). It is hard and expensive but it may well be necessary to have a science of the mind that speaks to aspects of the mind that are important to cognition outside the sterile lab and that generalizes to a substantial portion of the human population.

Conflict of Interest Statement

The authors declare that they have no conflict of interest.

Authorship Contributions

No new empirical finds were presented; credit is attributed to authors within the text where relevant. Dr. Randall Engle wrote the manuscript, with supporting help from Dr. Jessie D Martin in writing and editing.

References

Atkinson, R. C., & Shiffrin, R. M. (1968). *Human memory: A proposed system and its control processes*. pp. 89–195. *Psychology of learning and motivation* (Vol. 2) Academic Press.

Baddeley, A. D. (1966). The influence of acoustic and semantic similarity on long-term memory for word sequences. *Quarterly Journal of Experimental Psychology*, *18*(4), 302–309.

Baddeley, A. D., & Hitch, G. (1974). *Working memory*. pp. 47–89. *Psychology of Learning and Motivation* (Vol. 8) Academic Press.

Carpenter, P. A., & Just, M. A. (1975). Sentence comprehension: A psycholinguistic processing model of verification. *Psychological Review*, *82*(1), 45.

Clark, H. H., & Chase, W. G. (1972). On the process of comparing sentences against pictures. *Cognitive Psychology*, *3*(3), 472–517.

Conrad, R. (1964). Acoustic confusions in immediate memory. *British Journal of Psychology*, *55*, 75–84.

Conrad, R., & Hull, A. J. (1964). Information, acoustic confusion and memory span. *British Journal of Psychology*, *55*(4), 429–432.

Crowder, R. G. (1982). The demise of short-term memory. *Acta Psychologica*, *50*(3), 291–323.

Draheim, C., Harrison, T. L., Embretson, S. E., & Engle, R. W. (2018). What item response theory can tell us about the complex span tasks. *Psychological Assessment*, *30*(1), 116.

Engle, R. W., & Kane, M. J. (2004). Executive attention, working memory capacity, and a two-factor theory of cognitive control. *Psychology of Learning and Motivation*, *44*, 145–200.

Engle, R. W., Nations, J. K., & Cantor, J. (1990). Is "working memory capacity" just another name for word knowledge? *Journal of Educational Psychology*, *82*(4), 799.

Engle, R. W., & Oransky, N. (1999). Multi-store versus dynamic models of temporary storage in memory. In *The nature of cognition*. pp. 515–555.

Hebb, D. O. (1949). *The organization of behaviour*. New York: Wiley.

Hunt, E., & MacLeod, C. M. (1978). The sentence-verification paradigm: A case study of two conflicting approaches to individual differences. *Intelligence*, *2*(2), 129–144.

Lashley, K. S. (1951). . *The problem of serial order in behavior* (Vol. 21) Bobbs-Merrill.

Logie, R. H. (2018). Human cognition: Common principles and individual variation. *Journal of Applied Research in Memory and Cognition*.

Logie, R. H., Della Sala, S., Laiacona, M., Chalmers, P., & Wynn, V. (1996). Group aggregates and individual reliability: The case of verbal short-term memory. *Memory & Cognition*, *24*(3), 305–321.

Matzel, L. D., Han, Y. R., Grossman, H., Karnik, M. S., Patel, D., Scott, N., Specht, S. M., & Gandhi, C. C. (2003). Individual differences in the expression of a "general" learning ability in mice. *Journal of Neuroscience*, *23*(16), 6423–6433.

MacLeod, C. M., Hunt, E. B., & Mathews, N. N. (1978). Individual differences in the verification of sentence—Picture relationships. *Journal of Verbal Learning and Verbal Behavior*, *17*(5), 493–507.

Martin, J. D. (2018). Individual differences in prospective memory performance and the role of attention control (in preparation).

Martin, J. D., Shipstead, Z., Harison, T. L., Redick, T., Bunting, M., & Engle, R. W. (2018). Maintenance and disengagement in reading comprehension and vocabulary learning (submitted for publication).

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Newell, A. (1973). *You can't play 20 questions with nature and win: Projective comments on the papers of this symposium*.

Restle, F. (1965). Significance of all-or-none learning. *Psychological Bulletin*, *64*(5), 313–325.

Rosen, V. M., & Engle, R. W. (1997). The role of working memory capacity in retrieval. *Journal of Experimental Psychology: General*, *126*(3), 211.

Turner, M. L., & Engle, R. W. (1989). Is working memory capacity task dependent? *Journal of Memory and Language*, *28*(2), 127–154.

Shipstead, Z., Harrison, T. L., & Engle, R. W. (2016). Working memory capacity and fluid intelligence: Maintenance and disengagement. *Perspectives on Psychological Science*, *11*(6), 771–799.

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