Memory In Nature: A Study of Morphic Resonance Predictions on Learning[1]

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Abstract: *Objective.* Within the context of learning, morphic resonance predicts that a skill should become easier to learn as more people practice it due to the pattern of learning existing within a morphic field. Several studies have investigated this theory, with some providing preliminary support for its predictions. The objective of this study was to add to this literature by conducting three studies that used the online game Wordle. We hypothesized that as the day progressed, attempts needed to solve Wordle should decrease because of resonance from earlier players. *Method.* Study 1 used a questionnaire to collect Wordle scores and completion times in an experimental group that completed the official NYT Wordle and a control group that completed a custom Wordle. Studies 2 and 3 used WordleBot to collect data based on a random sample of Wordle players worldwide. *Results.* Study 1 did not find the predicted negative correlation between attempts and time of day in the experimental group. As expected, no significant correlation was found for the control group. The results of Study 2 revealed a significant increase in the percentage of players solving the puzzle from morning to evening on the first two guesses. These findings were not replicated in Study 3. *Conclusion.* Taken together, the findings suggest that if morphic resonance is at play, it is likely a subtle effect that is easily inhibited by factors such as conscious cognitive processes. It may thus require more refined experimental designs to be detected.

Keywords: morphic resonance, morphic fields, formative causation, learning, Wordle, WordleBot

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Highlights

- Morphic resonance suggests that patterns of learning become embedded within morphic fields, to which subsequent individuals learning the same skill can tune in, facilitating faster learning.
- We conducted three quantitative studies exploring the association between time of day and Wordle score. Morphic resonance predicts that Wordle should become easier to solve as the day progresses.
- Studies 1 and 3 did not support the hypothesis that as time of day progressed, Wordle should become easier to solve in fewer attempts.
- Study 2 found that the percentage of players solving Wordle from morning to evening increased on the first two guesses, perhaps indicative of morphic resonance.

Morphic resonance (MR) is a hypothesis put forth by Rupert Sheldrake suggesting that memory is inherent within nature (e.g., Sheldrake, 2012). The hypothesis proposes the existence of a group of fields—called morphic fields—that exist within and around self-organizing systems guiding them towards characteristic patterns of activity. One of the key features of morphic fields, which differentiates them from the traditional idea of a field as defined by physicists, is that they have an inherent memory (Watts, 2011). This memory forms the basis of the hypothesis of MR, through which each member of a system or species draws upon, and in turn contributes to, the collective memory within morphic fields. Through this process, the patterns we see in nature—such as an organism's physical form or patterns of learning and behavior—literally become embedded within morphic fields. As a result, these patterns become increasingly probable.

MR forms the basis of Sheldrake's hypothesis of formative causation, which suggests that organisms are subject to an influence from previous similar organisms (e.g., Sheldrake, 2012). For instance, once many people have learned a particular skill, that skill should become progressively easier to learn for subsequent individuals because that pattern of learning is embedded within a morphic field. Other individuals can tune into the morphic field through MR based on similarity—by being similar organisms in similar circumstances. This proposition radically differs from the conventional view of learning, which is assumed to be enabled by changes in brain activity (e.g., Kolb et al., 2019). It is thus unsurprising that MR has been controversial (Gomez-Marin, 2021) and even deemed "the best candidate for burning there has been for many years" (Maddox, 1981, p. 245). However, as Sheldrake (2012) points out, MR is an empirically testable hypothesis. The current study aims to add to the empirical literature on MR, specifically in relation to its predictions regarding learning.

Morphic Resonance and Learning: Predictions and Research

In the field of cognitive neuroscience, MR makes radically different predictions than conventional theories regarding memory. Contrary to the traditional assumption that memory is underpinned by physical traces in the brain, MR proposes that memory operates based on resonance and is not stored in the brain at all (Sheldrake, 1987, 2012). This conforms with current experimental evidence within neuroscience, because despite numerous attempts to locate such traces, they remain elusive (e.g., Abraham et al., 2019). Sheldrake (1987, 2012) further suggests that morphic fields may provide a basis for collective memory—similar to Jung's (1968) collective unconscious.

MR also has important implications regarding learning. Like memory, learning is conventionally assumed to be supported by physical changes in the brain (e.g., Kolb et al., 2019). Sheldrake (2012) proposes that learning is additionally facilitated by MR: patterns of learning become embedded within morphic fields. Through tuning into the morphic field of those who have practiced a skill before, MR predicts that learning should become easier, particularly if many individuals have previously practiced the skill. This type of MR concerns mental and behavioral fields—two types of morphic fields that influence mental activity and behavior, respectively.

Across a variety of disciplines, there is empirical research suggesting that patterns of behavior and learning are indeed inherited through means that remain unexplained. Several well-documented examples have been advanced of the inheritance of acquired characteristics—an idea that has been strongly opposed within biology (Liu, 2011). For instance, one study found that offspring of chickens raised in an unpredictable diurnal light rhythm displayed a similar foraging behavior to their parents, despite not being raised in those unpredictable conditions (Natt et al., 2009). Similarly, another study found that a conditioned fear response to a specific odor in mice can be passed onto offspring who have never been exposed to the odor (Dias & Ressler, 2014). Such transgenerational effects can extend to the second generation of offspring, such as the effects of acute parental exposure to predation risk in mice (Bhattacharya et al., 2023). The results of the latter study caused the researchers to conclude that "similar transgenerational responses are the rule rather than the exception in free-living organisms" (Introduction, para. 5).

A variety of mechanistic explanations have been advanced for this kind of inherited behavior—such as epigenetic inheritance which proposes that the acquired characteristics result in heritable changes in gene expression (Heard & Martienssen, 2014)—but MR provides an alternative (or complementary) explanation. Indeed, as one might predict based on MR, these types of inherited behavior are not limited to an animal's direct relatives. This suggests that mechanistic explanations are not sufficient to explain all instances of inherited behavior. For example, McDougall (1938) conducted an experiment on the hereditary transmission of learning by training rats to escape a water maze. The maze had two exits: one dim and one illuminated. The illuminated exit resulted in an electric shock—the rats thus had to learn to use the dim exit. Over the course of the 30-year experiment, McDougall's rats and their offspring showed a remarkable improvement in learning—a result he attributed to Lamarckian inheritance. Agar et al. (1954) repeated McDougall's experiment over a 20-year period, rectifying what they believed to be a fundamental weakness: the lack of a control line whose ancestors were not trained. Like McDougall's, the experiment obtained long duration trends of improvement, but these effects were not sustained. Agar et al. concluded that this forbade a Lamarckian interpretation and suggested that the changes in learning rate were correlated to the health of the rat colony. Such a finding is not inconsistent with MR, which does not preclude the operation of other factors. Of particular interest, is the parallelism between the performance of the trained and control lines, which "suggests that the changes were related to factors, not necessarily having any genetic basis, that influenced the rate of learning" (Agar et al., 1954, p. 315). Sheldrake (1987, 2012) suggests that such learning may be underpinned by MR: the new pattern of learning was in the morphic field of rats, to which other rats can tune in.

Similar progressive trends in learning have been found with respect to human skills. For example, a meta-review found that IQ test scores have increased over the last century—a phenomenon known as the Flynn effect (Pietschnig & Voracek, 2015). A variety of explanations have been advanced to account for this effect, such as better education (e.g., Teasdale & Owen, 2005), guessing effects (e.g., Must & Must, 2013), and increasing access to technology (Neisser, 1997). Individually, these explanations are unlikely to account for the full extent of IQ gains. Consequently, Pietschnig and Voracek (2015) concluded that the most likely explanation is a combination of factors. Interestingly, their meta-review revealed that gains were substantially stronger for fluid IQ (derived from reasoning-based tasks) than crystallized IQ (derived from knowledge-based questions). These findings are consistent with MR, which predicts that the patterns of learning derived from the reasoning-based tasks are embedded within a morphic field, facilitating better problem-solving for subsequent individuals completing the same tasks.

Several experiments have been specifically designed to test for learning-related factors in MR. In one, Mahlberg (1987) compared participants' ability to learn the real morse code to a novel code (devised by re-assigning the dots and dashes). The participants learned the real code significantly more accurately and, interestingly, subsequent participants also began learning the novel code increasingly accurately. Both findings are consistent with MR, and the latter may be explained by the resonance from previous participants learning the novel code—especially due to the specificity in the way they were learning the code throughout the experiment (Sheldrake, 2012). In another experiment, non-Chinese participants were exposed to both genuine and false Chinese characters and subsequently tested on which ones they recognized (Robbins & Roe, 2010). Consistent with the predictions of MR, they recognized significantly more of the genuine characters. This remained true for characters they had not been previously exposed to. Additionally, Dienes (1994) tested the speed at which participants recognized strings of letters—some real English words, and some non-words. The more often a non-word had been seen, the faster subsequent participants responded to it. This effect was statistically significant and is consistent with MR. However, no significant effect was found when Dienes repeated the experiment.

Similarly, other MR experiments have given inconsistent results. Monica England, an undergraduate psychology student, conducted an experiment testing two crossword puzzles a day before and a day after they were published by a London newspaper (described in Sheldrake, 2012). This experiment gave mixed results, with participants solving significantly more clues the day after publication with one crossword puzzle, but without change for the other. In a replication of Robbins' and Roe's study, Roe and Hitchman (2011) found that participants recognized more false than genuine Chinese characters, contrary to the predictions of MR. Similarly, Vernon et al. (2021) tested whether non-Chinese speaking participants implicitly preferred real versus decoy Chinese characters, and whether they were able to explicitly identify the real characters, as would be predicted by MR. The data did not substantiate these hypotheses and there was even a preference for the decoy characters. Indeed, it must be acknowledged that Robbins and Roe's initial successful results might be explained by factors such as cryptomnesia—an original idea that is in fact derived from a latent memory (Colman, 2015)—rather than MR.

If MR is at work, such inconsistencies in experimental results may be accounted for by several limitations. Sheldrake (1999) suggests that a potential weakness of small-scale experiments is that the resonance may be too weak to be detectible with only a few thousand boosters. This may explain the results in England's experiment since there likely were not enough people completing the crossword puzzle to produce a strong MR effect. Another limitation concerns whether a pattern being tested is truly a new pattern. For instance, Sheldrake (2012) discovered that some of the crossword clues were in fact recycled, which means that previous resonance may have interfered with the experiment.

Summary and Objective of the Current Study

Taken together, evidence for the potential impact of MR on learning is preliminary, but promising. Some studies have found null or mixed results, whereas others provide initial support for the ideas proposed by MR. The current study aims to contribute to this research by investigating MR using the online puzzle Wordle (The New York Times, 2022a). Wordle is a free online puzzle published by the New York Times (NYT) which gives users six chances to guess a particular word, with previous guesses indicating which letters the word includes, and whether those letters are in the correct place. Wordle resets with a new word every 24 hours and is played by millions of people every day (Katz & Bhatia, 2023). If memory is inherent within nature, as MR predicts, there should be a cumulative influence from previous players who have completed the puzzle. Consequently, Wordle should become easier to solve as the day progresses, as the solution will have been "boosted" by other players through the process of MR. Regarding the current study, the large number of daily Wordle players is expected to help combat the limitation that many small-scale MR studies face: resonance that is too weak to be detectible. Additionally, since Wordle resets with a new puzzle every day, it can be classed as a new-field test (a test that investigates a new pattern of activity) that should theoretically make the resonance easier to detect.

Interestingly, the NYT published an article claiming that more people than can be explained by chance—approximately one in 250—solve Wordle on their first guess (Katz & Bhatia, 2023). After analyzing Wordle data for four months, Dilger (2023) observed a similar trend and concluded that it must be the result of rampant cheating. Cheating is certainly a reality when it comes to Wordle—as was confirmed by Taparia's (2022) survey in which one in ten of 1,087 players admitted to cheating—but the question remains as to whether cheating is enough to explain these unexpected trends. An alternative explanation is MR. With this in mind, the current study evaluates whether Wordle becomes easier to solve as the day progresses, as predicted by morphic resonance, and these hypotheses:

Study 1 Hypotheses (Confirmatory):

1. There should be a negative correlation between Wordle score and time of day (i.e., the number of attempts taken to solve Wordle should decrease as the day progresses).
2. There should be no significant correlation between Wordle score and time of day for a control group completing a custom Wordle that has a small number of other players (null hypothesis).

Studies 2 and 3 Hypothesis (Confirmatory):

1. There should be a significant increase in the percentage of Wordle players guessing the correct word in fewer attempts from morning to evening, demonstrating an improvement in Wordle score.

The study hypotheses and analyses were not preregistered. The data for this study are available from the corresponding author upon request.

Method

Research Design

This research was split into three studies. Study 1 involved gathering participants' Wordle scores and included both an experimental and a control condition. The experimental condition collected participants' scores for the official NYT Wordle (i.e., the number of attempts it took them to guess the correct word). The control condition collected participants' scores for a custom Wordle—the solution to which was a word that had *not* been used by the NYT and was selected by Georgia Black. After completing either the official or the custom Wordle, participants were asked to complete an online questionnaire (described in more detail below). Study 1 examined the relation between two variables: participants' Wordle scores and time of day. Thus, Study 1 was correlational.

Studies 2 and 3 used WordleBot (The New York Times, 2022b) to assess the Wordle scores of randomly selected groups of NYT Wordle players. WordleBot is an online tool, provided by the NYT, that supplies comparative data of other players around the world who have played Wordle that day. Specifically, WordleBot randomly selects a large number of Wordle players and provides the percentage of players who guessed the correct word on each attempt, allowing for an assessment of whether there is a change throughout the day in the number of people who guessed the word in fewer attempts. Over a period of 12 days in Study 2, and 30 days in Study 3, GB completed the official NYT Wordle in both the morning and the evening, and subsequently used WordleBot to investigate whether there had been an increase in the percentage of players who guessed the word in fewer attempts throughout the day. Additional details about WordleBot are provided below. Both Studies 2 and 3 aimed to study the relation between Wordle performance and time of day. Study 3 took place approximately 7 months after Study 2 and was conducted to investigate whether the pattern of results in Study 2 would replicate over a larger number of days. Given that the researchers did not have control over when players completed Wordle, the research design for Studies 2 and 3 was a quasi-experimental comparison of groups. All three studies were granted ethical approval by the Alef Trust Research Ethics Panel (#ATREP2310).

Participants

Based on the assumption that the effect under investigation should apply to anyone who plays Wordle, Study 1 did not have many inclusion/exclusion criteria. Additionally, it was assumed that a large sample size that maximized diversity would help mitigate potential confounding variables such as individual differences in language ability and the difficulty of the Wordle target word on any given day. Consequently, anyone was allowed to participate provided they were over the age of 18 and capable of giving informed consent. Participants also needed to be native English speakers to mitigate the potential impact of English as a second language.

In total, Study 1 collected 332 responses for the experimental group and 272 responses for the control group (604 responses total). Twenty-one responses were excluded from the control group for the following reasons: 1) The respondent stated Wordle's solution as opposed to the control solution; 2) the respondent claimed to have guessed the word within 6 attempts but gave the wrong solution; 3) one participant made the authors aware of a duplication of their questionnaire response which was easy to locate on the spreadsheet and thus excluded. No responses were excluded from the experimental group. Therefore, the total number of analyzed responses were 332 for the experimental group and 251 for the control group (583 responses total). Participants were allowed to participate in Study 1 multiple times (provided the puzzle solution had changed), therefore this did not equate to 583 individual participants. Participants were only required to complete the demographics questionnaire

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the first time they participated in the study. Based on this criterion, we estimate that approximately 342 unique individuals participated in Study 1, (*n* = 117 for the experimental condition and *n* = 225 for the control condition).

The majority of Study 1 participants were female (61% and 60% of experimental and control participants, respectively), and were from the United States and Northern or Western Europe (41% and 38% of experimental participants, and 36% and 34% of control participants, respectively). Participants were on average 58.8 years old (*SD* = 16.1) in the experimental condition and 56.7 years old (*SD* = 14.9) in the control condition. The highest level of education for most participants was a post-graduate degree, followed by college/university (44% and 36% for the experimental participants, and 46% and 35% for the control participants, respectively). For Studies 2 and 3, WordleBot randomly selected an average of 641,303 and 696,690 morning Wordle players, and 1,745,345 and 1,779,495 evening Wordle players, respectively, across the 12 and 30 days that GB completed Wordle prior to using WordleBot (Study 2 morning range: 482,366 to 809,764; Study 3 morning range: 592,964 to 900,129; Study 2 evening range: 1,722,314 to 1,765,769; Study 3 evening range: 1,772,595 to 1,785,361). WordleBot does not provide demographic information for its participants.

Materials

Questionnaire

For Study 1, the questionnaire was created using Google Forms. The questionnaire took approximately five minutes to complete and included several demographic questions before proceeding onto the questions about Wordle. The two key pieces of information the questionnaire collected were: 1) how many attempts it took the participant to guess the word, and 2) at what time they did the puzzle (including their time zone). To indicate the time, participants were asked to select a 2-hour time window (e.g., 04:00-06:00). The questionnaire also included other questions to help inform the research, such as what the solution was (the word) and participants' perception of how easy the solution was (rated on a scale of 1 to 5, with 1 labelled "very easy" and 5 labelled "very difficult").

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Custom Wordle

The custom Wordles for the control condition were created using a free website that allows one to choose the target word and disseminate the puzzle via a link (Strive, 2022). The custom Wordles created on this website operated in the same way as the official NYT Wordle. The solutions chosen had *not* been used by the NYT Wordle. This was ensured by consulting a website that had posted an archive of Wordle's previous words. GB verified this site by checking that the NYT Wordle solutions corresponded to the website (which was updated daily). ChatGPT was used to provide a list of five-letter words that were not included in this archive. Six words were selected and cross-referenced with the archive to ensure that they had not already been used by the NYT Wordle. Three easy (*crisp*, *might* and *chair*) and three hard (*fable*, *hovel* and *nexus*) words were selected to counterbalance the potential ease of the word. This selection was based on GB's intuitive sense of the ease of the word. Each control word was used for approximately 5 days. The NYT Wordle solution was monitored daily to ensure that the NYT did not use the words currently being used for the custom Wordle.

NYT Wordle

The experimental condition required participants to complete the official NYT Wordle puzzle which is freely available online. The solution for the official NYT Wordle changes every day (see the Appendix for a list of solutions throughout the course of this study).

WordleBot

WordleBot uses the official NYT Wordle to produce its data. Two NYT subscriptions were purchased, which allowed access to WordleBot twice in one day. The WordleBot data is based on a sample of users that WordleBot randomly selects from individuals around the world who completed Wordle that day. The specific data collected from WordleBot for the current study were: 1) the sample size, 2) the percentage of players guessing the target word on each attempt (from one to six), and 3) the target word.

Procedure

Participants were recruited for Study 1 over a two-month period from two main sources: dedicated Wordle Facebook groups and personal social media outlets belonging to the researchers. Participants were asked to either complete the NYT Wordle, or the custom Wordle, and subsequently fill in the questionnaire described above. The questionnaire links were shared in alternating order until data collection needed to be closed due to timing constraints placed on the project, which was part of an M. Sc. dissertation. To minimize the risk of participants guessing the study's hypothesis and unintentionally influencing their Wordle performance, MR was not mentioned. Instead, participants were informed that the purpose of the study was to "explore factors that might influence people's Wordle scores." Participants were allowed to participate in both the experimental and control condition multiple times if they wished, because Wordle solutions changed regularly. Skip logic was used in the questionnaires so that participants did not have to read the study information or answer the demographic questions on subsequent attempts.

For Study 2, over a period of 12 days GB completed Wordle at 06:30-08:00 in the morning and collected the accompanying WordleBot data. Using a second account, this process was repeated at 22:30-00:00 in the evening. Thus, GB completed Wordle and collected the WordleBot data a total of 12 times in the morning and 12 times in the evening. The relevant WordleBot data were then entered into an Excel spreadsheet for analysis. For Study 3, this process was replicated over a period of 30 days with one difference: the morning data was collected at 06:00-06:30 and the evening data at 23:00-23:30.

Data Preparation

Prior to conducting the analysis for Study 1, the time of day that participants completed Wordle was converted into GMT (for both the experimental and control responses). This was done using an Excel formula and subsequently manually checked by GB for accuracy. Any responses consisting of a location and time zone that did not match were converted based on their stated location. Since Wordle is released at midnight for each local time zone, each "Wordle day" is longer than a 24-hour period. This meant that some converted times fell outside of the 24-hour GMT window and needed to be accurately classified as either occurring *before* or *after* the main period. For example, 06:00-08:00 in New Zealand converted to 17:00-19:00 GMT on the *previous* day. This would indicate that the participant completed Wordle later in the day when they were actually one of the first in the world to complete that day's puzzle. Consequently, such timeslots were labelled as "(pre)" to indicate that they occurred before the main GMT window and were analyzed accordingly as early completions for their respective Wordle day.

For Studies 2 and 3, the average sample sizes across the 12 and 30 days were calculated for both the morning and evening. The percentage of players who guessed the correct word on each attempt was also averaged across the 12 and 30 days tested. This resulted in 6 average percentages, representing each of the 6 attempts, for both the morning and the evening (12 in total for each study).

Statistical Analysis

Study 1

To test whether participants' Wordle scores were related to the time of day they completed the puzzle, a correlational analysis was performed on both the experimental and control responses. For both conditions, the Shapiro-Wilk test was conducted on both variables: time of day and attempts. The test revealed that the experimental data for time of day and number of attempts was not normally distributed, Shapiro-Wilk's $W = 0.93$, $p = < .001$, and $W = 0.91$, $p = < .001$, respectively. The test showed that the control data for time of day and number of attempts was not normally distributed either, $W = 0.99$, $p = 0.01$, and $W = 0.93$, $p = < .001$. Spearman's Rho was used to estimate correlations for both conditions.

Studies 2 and 3

To test whether there was an increase in the percentage of players guessing the correct word from morning to evening on each attempt, six two-sample z-tests for proportions were performed on the WordleBot data obtained in each study (i.e., one z-test comparing the percentage of players who guessed the correct word in the

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morning vs. evening for each of the six attempts). Effect size was estimated in Studies 2 and 3 using Cohen's *h*.

Results

Study 1

Descriptive Statistics: Experimental Group

The most frequent Wordle scores were 3 or 4, making up 33% and 38% of the responses, respectively (Table 1). The mean Wordle score was 3.81, meaning participants solved Wordle in an average of 3.81 attempts. Only 0.3% of respondents reported solving Wordle in 1 attempt (see Fig. 1)

Table 1

Frequencies of Wordle Score: Experimental Group

Number of attempts	Counts	% of total
1	1	0.3
2	22	6.6
3	109	32.8
4	127	38.3
5	56	16.9
6	13	3.9
7	4	1.2

Note. 7 attempts means that the participant failed to solve the puzzle.

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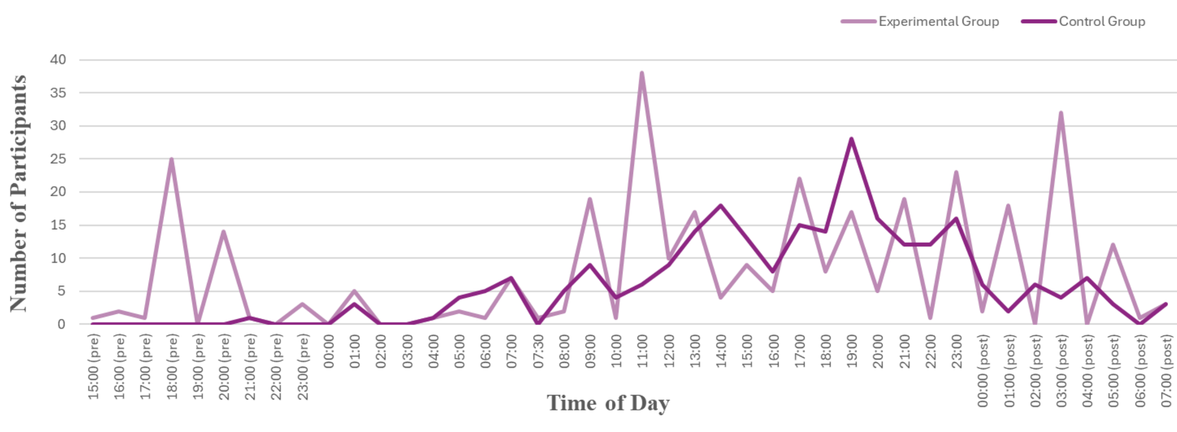
Figure 1

Frequencies of Time: Experimental and Control Group



Note. Time periods marked as (pre) or (post) fell before or after the 24-hour period (respectively) after being converted to GMT.

Descriptive Statistics: Control Group

Like the experimental data, the most frequent number of attempts taken to solve the control puzzles were 3 or 4, accounting for 24% and 31.5% of the total responses, respectively (Table 2). The mean Wordle score was 4.26, meaning participants solved the custom Wordles in an average of 4.26 attempts. Interestingly, 1.6% of respondents reported solving the custom Wordle in 1 attempt: 1.3% more than the experimental group.

Table 2

Frequencies of Wordle Score: Control Group

Number of attempts	Counts	% of total
1	4	1.6
2	10	4.0
3	60	23.9
4	79	31.5
5	57	22.7
6	23	9.2
7	18	7.2

Note. 7 attempts means that the participant failed to solve the puzzle.

Test of Hypothesis

The correlational analysis for the experimental group revealed a very small negative correlation between the time of day and number of attempts taken to solve Wordle, $rs(332) = -.03$, $p = .59$. This means that as time of day increased, the number of attempts taken to solve Wordle decreased (i.e., the Wordle score improved). However, the correlation was very small and not significant. Thus, the hypothesis for the experimental group was not supported. The analysis for the control group produced a very small negative, non significant correlation, $rs(251) = -.01$, $p = .86$. Thus the control group results were consistent with the null hypothesis.

Study 2

The results of the two-sample *z*-test for proportions for each of the 6 attempts can be seen in Table 3. The results revealed a significant *increase* in the percentage of Wordle players guessing the correct word from morning to evening for the first two attempts. For both attempts, the observed effect size was very small. Attempt three also showed a non-significant increase, with a very small effect size. In addition, the WordleBot data showed a *decrease* in the percentage of players guessing the correct word from morning to evening on the latter three attempts. For the fourth, fifth, and sixth attempts, the *z*-test indicated a very small, significant difference between the morning and evening samples, with a very small effect size. Overall, the pattern of results is consistent with the hypothesis, reflecting an increase from morning to evening in the proportion of players solving in fewer attempts, particularly in one or two attempts.

Table 3

Study 2 WordleBot Results: Two-Sample z-test for Proportions

	Attempt 1	**Attem. 2**	**Attem. 3**	**Attem. 4**	**Attem. 5**	**Attem. 6**
Morning %	0.6	4.7	30.63	68.5	90.77	98
Raw number	3,848	30,141	196,431	439,293	582,111	628,477
Evening %	0.7	4.92	30.72	68.24	90.43	97.85
Raw number	12,217	85,871	536,170	1,191,023	1,578,315	1,707,820
Direction of trend	Increase	Increase	Increase	Decrease	Decrease	Decrease
z-score	8.38	7.01	1.34	3.83	7.95	7.15

p-value	< .001	< .001	.181	< .001	< .001	< .001
Significant	Yes	Yes	No	Yes	Yes	Yes
Cohen's *h*	0.012	0.01	0.002	0.0056	0.012	0.011

Note. "Morning %" and "Evening %" refer to the average percentage of the WordleBot sample guessing the correct word on each attempt across the 12 days. "Raw Number" is the raw number of participants who guessed the correct word on each attempt based on the average morning (641,303) and evening (1,745,345) sample sizes (these raw numbers are cumulative, including the number of participants who completed Wordle on the previous attempts). These average sample sizes were calculated across the 12 days tested.

Study 3

The results of the two-sample *z*-test for proportions for each of the attempts can be seen in Table 4. The results revealed a significant *decrease* in the percentage of Wordle players guessing the correct word from morning to evening for five of the six attempts. A non-significant decrease was found for the second attempt. For all attempts, the observed effect size was very small. The hypothesis was thus not confirmed in Study 3.

Table 4

Study 3 WordleBot Results: Two-Sample z-test for Proportions

	Attempt 1	Attem. 2	Attem. 3	Attem. 4	Attem. 5	Attem. 6
Morning %	0.56	4.7	27.46	61.99	84.71	94.81
Raw number	3,901	32,744	191,311	431,878	590,166	660,532
Evening %	0.53	4.66	27.24	61,67	84.50	94.70
Raw number	9,431	82,924	484,734	1,097,415	1,503,673	1,685,182
Direction of trend	Decrease	Decrease	Decrease	Decrease	Decrease	Decrease
z-score	2.9	1.34	3.49	4.66	4.11	3.48
p-value	.004	.180	< .001	< .001	< .001	< .001
Significant	Yes	No	Yes	Yes	Yes	Yes
Cohen's *h*	0.0041	0.0019	0.0049	0.0066	0.0058	0.0049

Note. "Morning %" and "Evening %" refer to the average percentage of the WordleBot sample guessing the correct word on each attempt across the 30 days. "Raw Number" indicates the raw number of participants who guessed the correct word on each attempt based on the average morning (696,690) and evening (1,779,495) sample sizes (these raw numbers are cumulative, including the number of participants who completed Wordle on the previous attempts). These average sample sizes were calculated across the 30 days tested.

Discussion

Study 1 did not find a significant correlation between time of day and Wordle score in the experimental or control groups. The data from the experimental group therefore did not support the hypothesis that as time of day increased, Wordle score should improve (i.e., the number of guesses taken to solve the puzzle should decrease). Study 2 found a significant *increase* in the percentage of players guessing the correct word from morning to evening on the first two attempts, and a significant decrease in the percentage of players guessing the correct word from morning to evening in four, five, or six attempts, which may be partially explained by successful solving on earlier attempts. The data from Study 2 was thus in line with the hypothesis that as time of day increased, a greater percentage of players should guess the correct word in fewer attempts (demonstrating an improvement in Wordle score). The significant increase on the first two attempts was not replicated in Study 3, which found *decreases* across all six attempts.

Relation to Existing Research and Theory

The results from Studies 1 and 3 did not confirm the hypothesis that Wordle would be easier to solve as the day progressed, in line with other experiments which have failed to produce results in support of MR. Roe and Hitchman (2011), for instance, found that their participants recognized more imitative Chinese symbols than genuine ones. Similarly, Vernon et al. (2021) found that their participants showed an implicit preference for decoy over real Chinese characters.

The simplest explanation for the results in Studies 1 and 3 is that MR is not at work, which is a possibility. However, several other factors that might have prevented an MR effect from being found are worth considering. One explanation for the results of Study 1 concerns the potentially subtle effects of MR, which may result in a small effect size that requires a large sample size to be detected. Sheldrake (1999) suggests that MR may be too weak to be detected with only a few thousand boosters. This might explain why one of the crosswords tested by Monica England did not produce a significant effect: the London newspaper which published the crossword likely did not have enough readers to create a strong enough resonance effect. The use of Wordle in the present study was expected to combat this limitation, given that it is played by millions of people. However, the analysis in Study 1 was based on 332 experimental responses (and 251 control responses) – perhaps this sample size was not sufficient to detect MR. In Studies 2 and 3, the sample sizes were much larger, and Study 2 did provide some evidence of Wordle becoming easier to solve as the day progressed, however Study 3 did not replicate this finding. It would thus be helpful for future research on Wordle to conduct additional, well-powered studies in order to further explore these potential effects. In addition, the small effect sizes found in the current research mirror many studies of psi phenomena that have found similarly small effect sizes (e.g., Cardeña, 2018). Small effect sizes are common in controversial research areas because otherwise, modest sample sizes would routinely be able to reject the null hypothesis and the research would thus not be as controversial (Cohen, 1977). As explained by Rosenthal (1986) in his analysis of the issue of successful replication, a small effect size does not mean that the effect is of no practical importance.

Another consideration worth exploring is the potential impact of distance. Vernon et al. (2021) suggest that the distance between their participants (in the UK) and the resonance they were trying to detect (in China) might have reduced the signal intensity of the resonance. Similarly, Sheldrake (2012) tested participants' ability to recognize two hidden images before and after one of those images was broadcast to a British TV audience. Sheldrake found that there was a significant *increase* in the number of European participants recognizing the image after the broadcast, however, the effect was not replicated in North America. Sheldrake (2012) suggested that a potential explanation is that the European participants may have been more "in phase" with the British TV audience than the North American participants because of the time difference. If this explanation is correct, it raises the question of whether the resonance from Wordle would be easier to detect if all boosters (and study participants) were in one location. In reality, Wordle players are spread across the globe, perhaps producing a less concentrated resonance effect.

It is also worth considering whether Wordle is an ideal candidate for testing MR. Sheldrake (2012) suggests that old-field tests—which attempt to detect resonance from previously established skills—may be less effective than testing novel skills. This is because it will be difficult to detect a change in the resonance of previously established skills that already have resonance built up. Conversely, new-field tests utilize new patterns of activity that will naturally have less interference. Wordle might be classed as a new-field test in the sense that the puzzle itself resets every 24 hours. However, the solution to each day's puzzle is an already-established English word. According to MR, words read by millions of people should be associated with morphic fields that facilitate the perception of those words (Sheldrake, 2012). Perhaps this makes it difficult to distinguish between resonance that has been built up solely from players completing the puzzle and the cumulative resonance built up from the use of the English words in general. In contrast to this, Mahlberg's (1987) experiment used a novel morse code (made up of random strings of dots and dashes) that is unlikely to be associated with any other existing resonance. This might explain why Mahlberg's experiment yielded statistically significant results in line with the predictions of MR while the current study produced mixed results.

In contrast to Studies 1 and 3, the increase in correct guesses from morning to evening seen in the first two attempts in Study 2 is in line with the predictions of MR: that earlier players will have boosted the solution, making it easier for subsequent players to guess the correct word by tuning in to the morphic field of earlier players. This finding mirrors other experiments that have produced data in line with the predictions of MR. For example, in Mahlberg's (1987) experiment comparing participants' ability to learn real versus novel morse code, participants started to learn the novel code progressively more quickly as the experiment went on. Like the Study 2 data, this suggests that the more people practice a particular task, the easier it might become for subsequent individuals practicing the same task, as predicted by MR. Several other experiments (outlined in the literature review) have also produced statistically significant results that support the predictions of MR (e.g., Dienes, 1994; Robbins & Roe, 2010).

The Study 2 data also showed a statistically significant *decrease* in the number of players guessing the correct word from morning to evening for the latter three attempts. Such decreases are expected when a greater proportion of players solve the puzzle earlier, but the specific pattern observed in this study might also be informative about the nature of Wordle and how players experience MR. Vernon et al. (2021) suggest that explicit memory processes generally require greater conscious cognition. This might allow more time for unhelpful conscious processes to interfere and potentially negate any MR effects. Indeed, Wordle is a game that relies on conscious cognitive processes: players use the clues from previous attempts to inform their subsequent guesses and draw upon their memory of existing words. This is certainly true for the latter attempts, but for the first two attempts, players have either no or very few clues to work from. They are thus less reliant on conscious cognitive processes and perhaps more open to unconscious processes such as intuition. As Vernon et al. (2021) suggest, this may mean that during the first two attempts, MR effects are less likely to be influenced by other cognitive processes. Therefore, perhaps the WordleBot data is indicative of MR being experienced as intuition for the first two attempts but being inhibited by other cognitive processes for the latter three attempts.

This hypothesis conforms with evidence from psi experiments, which suggest that fast-thinking protocols are likely to be more effective because they prevent conscious cognitive processes from interfering with the automatic nature of psi (Bem et al., 2015). Similarly, research on cognitive priming has suggested that subliminal stimuli produce greater changes in learning than consciously recognized stimuli (Bornstein, 1989). This is potentially because of a lack of counter-control mechanisms (i.e., conscious processes that scrutinize attitude changes induced by stimuli), which minimize the impact of consciously recognized stimuli (Kihlstrom, 1987). Indeed, the fact that a significant proportion of players in Studies 2 and 3 were able to guess correctly on the first attempt is surprising, given that such guesses must rely entirely on intuition (assuming that the players are not cheating). This result mirrors Dilger's (2023) finding: based on four months of WordleBot data, at least five times as many people were guessing the correct word on their first attempt than would be expected by chance. These findings from Dilger (2023) and Studies 2 and 3 are highly unexpected and are practically very important. In Study 3 for instance, the percentage of players guessing the correct word on attempt one never fell below 0.3%, which is remarkably higher than the 0.04% that would be expected based on the 2,315 possible target words (Dilger, 2023). An alternative explanation for these unexpected results is cheating which is discussed in the limitations section below.

Limitations and Alternative Explanations

This study is subject to a variety of methodological limitations that should be considered alongside the results. First, with regard to Study 1, the data relied upon self-reporting. Although several responses were excluded from the analysis to try and mitigate the risk of inaccuracy, it is unlikely that this risk was eliminated altogether. For instance, some responses indicated that the time the participant claimed to have completed Wordle may have been inputted incorrectly (i.e. AM instead of PM). With no way of verification, such responses had to be assumed accurate and included in the analysis.

A further limitation concerning Study 1 stemmed from participants being permitted to participate multiple times. This was intended to maximize responses but resulted in almost half of the responses coming from a small number of people who participated on consecutive days. There is thus the risk of individual characteristics—such as a participant being particularly good or bad at word puzzles—impacting any potential MR effects. With regard to the control group, one limitation is that the number of responses across the six custom Wordles were not balanced: more responses were collected for the difficult words. Furthermore, the six control words were selected by the researcher based on an intuitive assessment of their ease/difficulty, rather than a data-based decision. In addition, both the experimental and control group participants were primarily located in the United States and Northern or Western Europe, and most were female, raising concerns regarding the representative nature of the findings.

Also, with regard to Studies 2 and 3, some might argue that the WordleBot sample sizes are too large because at that scale, any effect—even very small effect sizes—can be statistically significant (Hand, 2015). Indeed, the numeric differences between the morning and evening samples were often very small (e.g., 0.6% vs. 0.7%), yet had large *z*-scores and high statistical significance. In these instances, it is helpful to consider the effect sizes, which were all very small and thus prevent one from over-emphasizing the high significance. These findings therefore raise questions around practical versus statistical significance. In other words, is a difference between 0.6% and 0.7% practically meaningful or useful, particularly when the effect size is so small? An important consideration here is that small effect sizes can carry profound implications. For example, if the small differences between morning and evening on attempt 1 cannot be attributed to cheating, other factors might be at play. Future research can use the results of the current study to explore what those factors might be. It will be helpful for future research to strike a balance between effect size and sample size, by conducting pre-registered power analyses to ascertain the minimum sample size required to detect potential MR effects, which may be subtle. It should be noted that reducing the WordleBot sample size would require collecting all of the study data earlier in the day, which would undermine the tool's ability to detect potential differences between morning and evening, which is crucial for testing MR. Instead, a questionnaire-based method—like the one used in Study 1—would allow for Wordle scores to be gathered at a sufficiently large, but more manageable, sample size.

One difficulty with any experiment seeking to test for MR is the ability to distinguish MR from other variables. Regarding Wordle, the most obvious alternative explanation for better performance is cheating, which is a much more straightforward explanation than MR experienced as intuition. However, although it is certain that some players do cheat (as confirmed by Taparia's (2022) survey of 1,087 American Wordle players, which found that 10% admitted to cheating), the findings of Studies 2 and 3 and the results of Dilger (2023) suggest that the number of people getting Wordle right in one attempt is much greater than chance. Dilger (2023) concluded that this effect can be explained by rampant cheating—though he did suggest that players should be more likely to cheat as the game progresses. It seems reasonable to assume that cheating would increase as players use up their guesses and become increasingly frustrated. However, it makes little sense why players would cheat on their first try on a one-player game—thus calling into question whether these trends can be entirely explained by cheating. Moreover, the fact that success rates decreased in the evening in Study 3 (and for attempts four, five, and six in Study 2) is not easily compatible with cheating. If cheating were widespread, it might be expected to increase as the day progressed, as more people knew the answer and shared it on social media. Taparia's (2022) study did not specify on which attempts players are most likely to cheat, so future research using Wordle to test for MR might benefit from more thoroughly surveying players' cheating behaviors.

Another potential confounding variable is the impact of circadian rhythms, which have been found to regulate a variety of cognitive functions. For example, some research suggests that working memory, which plays an important role in advanced cognitive processes such as problem solving, usually reaches peak capacity at noon (Xu et al., 2021). Consequently, participants might perform better on Wordle at certain times because of their unique circadian rhythm.

Furthermore, Robbins and Roe (2010) argue that it would be useful for MR to be distinguished from other forms of anomalous cognition. They suggest that their findings—which were consistent with MR—might also be explained by mechanisms such as large-scale telepathy. Another plausible psi explanation is precognition—the ability to anticipate future events through an unknown inferential process—which has been supported by a growing body of empirical literature (e.g., Bem, 2011; Bem et al., 2015). Indeed, research has suggested that psi performance might also be mediated by circadian cycles (e.g., Luke et al., 2012), further elucidating the difficulty in teasing these different variables apart. Future research would thus benefit from designing experiments, as far as is feasible, in which the impact of these variables can be separated from MR. With regard to anomalous cognition, Sheldrake (2019) suggests that the difference between MR and telepathy is that the former is a bulk effect which often involves complete strangers, whereas the latter typically occurs between closely bonded people. Similarly, precognition may struggle to account for a global increase in Wordle scores unless it is assumed that all players are independently accessing the same future outcome.

As with MR, both telepathy and precognition face the challenge of lacking a well-established scientific mechanism. Nevertheless, several theoretical contenders have been proposed: some psi researchers draw parallels to quantum phenomena such as entanglement (Bem et al., 2015), while Sheldrake (2012) proposes that MR operates through morphic fields, which he argues may be compatible with physical fields as described in contemporary physics. Compared to MR, telepathy and precognition have the advantage of requiring fewer new theoretical constructs, as they rely on information transfer rather than proposing entirely novel fields. As a result, they would allow for players to "sense" the correct answer without the need to posit a collective memory or field-based mechanism.

Future Research

It would be useful to repeat Study 1, rectifying the limitations identified above. One avenue would be to conduct the experiment in a controlled setting in which participants are tested in person. This would allow for the following adjustments to be made: 11) pre-testing participants for relevant skills and controlling for differences in the analysis; 2) ensuring that the data collected is as accurate as possible; 3) eliminating, as far as is feasible, conventional explanations such as cheating and circadian rhythms; and 4) conducting the experiment for a longer period. The disadvantage of this approach over an online approach is that it would be more difficult to test a larger sample size. Another approach would therefore be to repeat the online experiment carried out in Study 1, this time aiming for a larger sample size, which would hopefully make the experiment more sensitive to MR. It may be wise to not allow repeat participants, unless the researcher is confident they can garner enough responses to counterbalance the risk of individual characteristics (such as memory and problem solving skills) drowning out any MR effects. The questionnaire could also be adjusted, as far as is feasible, to alleviate the risk of incorrect data being inputted (e.g., changing times from 04:00 to 04:00AM).

An additional approach would be to repeat Studies 2 and 3 with a longer period between the morning and evening samples. This could be done by collecting data in the morning and evening of the earliest (e.g., New Zealand) and latest (e.g., Hawaii) time zones respectively, to ensure that the early sample has as small of an MR effect as possible. Such a refinement could make the experiment more sensitive to MR if it does exist (see Black et al., in press, for an example of this approach).

Another avenue for future research would be to test tasks that could be considered more novel—such as the novel morse code in Mahlberg's (1987) study or the strings of random letters used in the studies by Dienes (1994). If MR is at play, such experiments might help differentiate resonance from related factors (such as the resonance from the historical use of English words), making it potentially easier to be detected. This might be most effective with tasks and experimental designs that require minimal conscious cognitive processes. A methodological challenge for future research will be balancing the need to distinguish MR effects from psi phenomena such as telepathy (e.g., by using procedural tasks that are less sensitive to extrasensory perception), while also employing tasks than minimize conscious cognitive interference and theoretically make experiments more sensitive to MR.

Summary and Conclusions

The current study aimed to add to the empirical literature testing the predictions of MR, specifically with regard to learning. Taken together, the results of the current study suggest that if MR is at play, it is likely a subtle effect that might require more refined experimental designs to be detected. Several considerations and limitations have been highlighted in the current study that future research could address to further explore the predictions of MR. The findings also suggest that future research might benefit from investigating the relation of MR to other cognitive processes that might inhibit it.

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Appendix
Wordle Solutions Throughout the Study

AFTER	BOSSY	CORER	EVOKE	GUSTY	LINER	PASTA	SMALL	THESE	VERGE
AGING	BRASS	COURT	EXPEL	HALVE	LITHE	PHONE	SNAKE	THING	VINYL
AISLE	BRIEF	DAISY	FAITH	HANDY	LOCAL	RELIC	SPENT	THREE	WEIRD
ALIVE	BRUTE	DEBIT	FINAL	HEARD	LUNCH	REPEL	STEAM	THREW	WOULD
ALOOF	BUILT	DECAY	FLUNK	HOUSE	LUNGE	RERUN	STILL	TOPIC	
APART	BULKY	DELAY	FUNNY	JOINT	MICRO	ROUTE	STOLE	TORCH	
BACON	CABLE	DOING	GAMUT	KNAVE	MOMMY	SALTY	STONY	TOUCH	
BEAUT	CARVE	EASEL	GLOBE	LARGE	MURAL	SCANT	TABLE	TUNIC	
BLOCK	CHILD	EMBER	GRACE	LEARN	NORTH	SHOUT	TALON	TWEAK	
BLOND	CLEFT	ERUPT	GRANT	LEGGY	OWNER	SLOPE	THANK	TWIRL	