To investigate the Role of Attention in Number –Time Interaction

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CERTIFICATE

This is to certify that the thesis titled, "To investigate the role of attention on Number-Time Interaction," which is being submitted, in partial fulfillment of requirements for the award of the degree of Master of Arts in Psychology, to the School of Humanities and Social Sciences, Thapar Institute of Engineering and Technology, Patiala, is a bonafide work carried out under the supervision of Dr. Anuj Kumar Shukla, Assistant Professor, School of Liberal Arts and Sciences, Thapar Institute of Engineering and Technology, Patiala, and that no part of this project has been submitted for the award of any other degree.

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This is to certify that the above statement by the student concerned is correct and true to the best of my knowledge.

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DECLARATION

I, Avneet Kaur (862102003), a student of M.A. Psychology (2022-2023), School of Humanities and Social Sciences, Thapar University, Patiala, has completed the study titled, "**To Investigate the Influence of Attention in Number-Time interaction."**

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Abstract

We need to be able to represent temporal, geographical, and numerical data if we are to comprehend the environment we live in. Numerous cognitive, neurological, and developmental models have been developed to explain how we track quantity because of the prevalence of quantitative representations in the natural world.A theory of magnitude (ATOM), one of the most well-known theories of magnitude processing, postulates that a generalized magnitude system processes space, time, and numbers; hence, the magnitude dimensions may possibly interact.The ATOM theory has received support from numerous behavioral and neuropsychological investigations. Even while there are many parallels between how time, space, and number are represented, an expanding corpus of literature demonstrates startling dissociations in how each quantity is thought of. However, the magnitudes connected to time and number are processed through different mechanisms, according to more recent research that showed evidence in favor of domain-specific magnitude processing. Due to the contradictory results, it is unclear whether these magnitudes are processed individually or through a single processing mechanism. In the present study, we want to examine the influence of attention on number-time interactions. To investigate this we conducted an experiment using a temporal comparison task wherein we presented small numerical magnitude (1) and large numerical magnitude (9) in two different colors Red and Gray, for varied durations. The results demonstrate that there was overestimation of duration judgment in case of large numerical magnitude presented in red color as compared to small numerical magnitude in red color but no such differences were seen for numerical magnitude that was presented in gray color. The results suggest that general cognitive processes like attention and arousal, rather than the common magnitude system, may be responsible for the influence of visual numbers on temporal processing

Key Words: Magnitude Processing, Cognitive processes, ATOM, Perceived duration

TITLE-To Investigate the Role of Attention in Number–Time Interaction

1 INTRODUCTION

We are constantly exposed to temporal, geographical, and numerical data. It may not come as a surprise that infants, kids, adults, and even nonhuman animals rely on the amount of information to navigate the world, given the fundamental nature of quantity processing (Geary &vanMarle, 2016). Evidence (Skagerlund&Träff, 2016)that basic numerical skills may underlie formal academic achievement in humans further emphasize the pervasiveness of quantity processing (Bonny & Lourenco, 2015). Given the prevalence and significance of quantity representation(Holloway & Ansari, 2009), it is crucial to comprehend how fundamental quantitative processing works(Mazzocco, Feigensoneetet al., 2011).

1.1 A Theory of ATOM

There are a number of theories that attempt to explain how amounts are represented. The common magnitude system is the most noticeable and the article's main topic. (Meck & Church ,1983) were the first to propose that a single, shared cognitive system (the analog magnitude system, or AMS), situated within a particular neural locus, was in charge of processing time and number through experiments in which rats were able to generalize rules in one domain (e.g., time) to another domain (e.g., number). (Walsh, 2003) proposed an extension of this Theory, the Theory of magnitude (ATOM), which asserts that time, space, and number are each represented by a shared magnitude system in which a common metric for action particularly connects quantities. (Walsh, 2003) contends that sensorimotor activities are facilitated by processing quantities through a single system. Although (Bonn & Cantlon, 2012) concur that numbers are expressed similarly, they think ratio calculations—rather than actions—are the common denominator. This viewpoint contends that rather than focusing on the actual quantities themselves, comparisons between two of the same quantities (number vs. number) or two distinct quantities (number vs. time) depend on keeping track of the ratios between them.

1.2Behavioral evidence for the existence of a common magnitude system

A wealth of behavioral data has undoubtedly supported the ATOM model. For instance, studies by (Casasanto & Boroditsky, 2008) suggest that the interaction between time and space appears to transmit a symbolic representation of time along a line directed from left to right. According to the significant finding, lengthy durations are represented(Vicario et al.,2007) on the right of a temporal line,(Frassinetti et al., 2009), whereas small durations are shown on the left(Merritt et al., 2010). In a temporal estimating test, it has been discovered that depending on where the durations are along the line, left stimuli tend to generate biases towards short durations.(Vallesi et al., 2008) In contrast, right stimuli tend to induce biases towards long durations(Vicario et al., 2008)

More significantly, the Spatial-Temporal Association of Response Codes (STEARC) effect theory (Ishihara, Keller, et al., 2008) appears to further support the hypothesis that time is spatially represented along the left-right axis (Casasanto & Boroditsky, 2008). Study involved asking participants to hit one of two answer buttons based on whether a probe's timing was earlier or later than anticipated based on the clicks that came before it. According to the findings (Ishihara et al., 2008), correct responses were associated with late-onset timing and left responses with early onset timing.

The interaction between time and space appears to support the concept of a mental timeline (MTL), in which short temporal durations are represented on the left side of a space and long temporal durations on the right side using a left-to-right mapping (Santiago et al., 2007;Torralbo et al., 2006).

The mental number line (MNL), which appears to depict numbers along a horizontal left-to-right line (Moyer & Landauer, 1967; Restle, 1970), is a metaphor comparable to the mental timeline (MTL). The discovery of the Spatial-Numerical Association of Response Codes (SNARC) effect is what gave rise to the MNL's spatial nature (Dehaene, Bossini, &Giraux, 1993). The left key is used more quickly in a parity task to respond to tiny numbers, whereas the right key is used more quickly to reply to high numbers (Dehaene et al., 1993; de Hevia et al., 2008; Fias & Fischer, 2005; Gevers &Lammertyn, 2005). Multiple cognitive tasks have been used to reproduce the SNARC effect (Wood &Nuerk, 2008).

Notably, the SNARC effect manifests even when the magnitude processing is not necessary for the task, indicating that magnitude information is automatically activated (Fias et al., 1996; Fischer et al., 2003).

There has recently been evidence of a relationship between time and number magnitude. The large stimuli (e.g., eight or nine dots) were perceived as having a longer duration in a duration comparison task that used a Stroop-like interference (Xuan & Zhang, 2007)—according to research that supports this conclusion merely glancing at numbers results in a bias in temporal tasks that is dependent on the size of the number (Cappelletti et al., 2009; Lu et al., 2009; Oliveri et al., 2008; Vicario et al., 2007,2008). The participants in the creative time bisection task were instructed to pause an imaginary mental timer midway through a reference cue with a range of duration and amplitude (the numerals 1, 2, 8, and 9).

The bisection reaction times were reduced for small numbers whereas they were increased for high numbers (Vicario, 2007). Similarly, in a task involving time estimate, participants had to decide whether a test stimulus's duration was longer or shorter than a previous reference stimulus (a number 5 lasting 300 ms). According to the findings (Cappelletti et al., 2009; Lu et al., 2009; Oliveri et al., 2008; Vicario et al., 2008), a low number (such as 1) led to underestimate and a high number (such as 9) led to overestimation of the perceived length.

Study conducted by Kiesel & Vierck, 2009,where they employed a parity judgment task within a traditional SNARC paradigm, with the addition of dit-dah (Klapp & Erwin, 1976) responses related to the time domain. Definitively, the dah response denoted a large duration, whereas the dit response denoted a short duration. According to the findings, there is a Time-Numerical Association of Response Codes (TiNARC) effect, which links small numbers to brief response times and large numbers to lengthy ones (Kiesel & Vierck, 2009; Casarotti et al., 2007; Müller & Schwarz, 2008; Turconi et al., 2006).

Timing and mathematical skills (Brannon &Suanda, 2007; Feigenson, 2007; vanMarle& Wynn, 2006) have similar developmental paths.These results imply that either shared mechanisms or distinct mechanisms with similar properties facilitate time and numericalcalculations. Typically, a Stroop-like paradigm is used to investigate whether two tasks involve identical or interdependent processing stages. For instance, other studies (Henik &Tzelgov, 1982; Kadosh et al., 2007; Schwarz &Ischebeck, 2003) have shown that task-irrelevant knowledge about numerical magnitude can alter the comparison of the physical sizes of two numbers and vice versa. Participants' numerical and size magnitude judgments were more rapid and accurate when it was congruent, compared to when the magnitude information in the two dimensions was incongruent. There has also been evidence of a similar automatic link between numerical processing and action planning (Andres et al.,2004; Lindemann, Abolafia et al., 2007). The size of a task-irrelevant number printed on an object affected people's grip aperture and response time when they reached for it or imagined doing so (Andres et al., 2008; Andres & Ostry, 2008;Chiou & Chang, 2009).

Studies supporting the common magnitude system have demonstrated overestimating duration for a big magnitude and underestimating duration for a small magnitude relative to each other (Chang & Ovid J L, 2011) found reproduced durations to be shorter for small numbers (e.g., 1) than for large numbers (e.g., 9)It's conceivable that the representation of short and long periods, respectively, is automatically activated by small and large numbers, and that Such activation may skew the results of reproduction.

When reproduction responses were started, numbers emerged instead of the expected pattern. We reason that a small number triggered the representation to explain this reversal short, compressing the response interval in the subject's mind. Participants used longer key presses to offset this impact. Similar to how a large number appeared, a long-duration representation was triggered, and participants reduced the length of their key presses to account for this effect.

This provides strong evidence that the effect of quantity magnitude on temporal processing does not result from a simple, rigid mapping between numbers and specific responses but rather arises from the influence of numerical magnitude on temporal processing, which converges with recent findings in demonstrating a close relationship between numerical and temporal processing.

The Stroop-like interference paradigm further reveals the influence of numerical magnitude on temporal judgment. These findings support the hypothesis that a shared magnitude representation underlies the domains of quantity and time. These findings, however, can also be explained by a straightforward mapping between stimulus types (such as small numbers) and response options (such as brief durations).A participant might merely associate one specific stimulus characteristic with one response label without accessing the magnitude representation while also associating the opposing stimulus characteristic with the other response label in accordance with such a line of thinking.

A cross-domain adaptation paradigm has demonstrated another type of quantity interference. Participants in this experiment are initially presented with a spatial prime consisting of two circles with varying sizes. The circles vanish after a predetermined time and are replaced with dot arrays. The next step is to invite participants to choose which dot array has the most elements. Participants were more likely to select the more numerous of two arrays when the choice was preceded by a larger circle when comparing large numerosities because judgments are biassed by the previously presented spatial display (Zimmermann & Fink, 2016; Burr & Ross, 2008). These statistics offer more proof that location information can skew numerical conclusions.

1.3 Neuroimaging Studies to Support the standard magnitude system

In addition to behavioral studies, a small number of neuroimaging studies have backed the concept of common magnitude processing and shown that the prefrontal and parietal cortices in the brain engage in cross-domain magnitude interaction (Hubbard et al., 2005; Bueti & Walsh, 2009; Hayashi et al., 2013; Skagerlund et al., 2016). It has been suggested that when magnitudes from various dimensions are processed concurrently, such cross-domain magnitude interaction may also emerge through automatic analogical processing. The frontal and parietal brain regions are also involved in this type of analogical processing (Bunge et al., 2005; Speed, 2010; Vicario & Martino, 2010).

The right inferior parietal cortex (rIPC), the subject of numerous fMRI, EEG ,and neuropsychological research, is crucial for time perception. Pure temporal deficits might not be as common (and certainly not as sought after) as spatial and visuomotor deficits after parietal lesions. Short-duration estimation tasks were administered to a patient with left spatial neglect, and the patient consistently overestimated the durations of stimuli provided in the neglected space and underestimated the durations of stimuli shown in the good field

Many studies that look at various aspects of temporal, spatial, and numerical processes engage the parietal cortex. While tasks involving numbers may cause the parietal lobes to become activated bilaterally, spatial and temporal cues reliably activate the right inferior parietal cortex. Instead of exact computation, which depends on language, the right parietal activity in number of tasks is typically related to comparison or estimation. A time-related activation of the right parietal cortex has not always been observed in research. This appears to be the case when other magnitude judgments are employed as controls (e.g., space, quantity, intensity), thus removing the right parietal time-related activity. A study that did discover a time-related activation in the rPPC when a non-magnitude control was used also showed that this activation disappeared when a magnitude control (intensity discrimination) was used. When intensity discrimination is utilized as a control, other research have not been able to elicit time-unique, right parietal activations. Tracy et al. utilized Mental arithmetic as a control, who also failed to detect a right hemisphere activation that distinguished between number and time processing. Numerous studies using transcranial magnetic stimulation (TMS)have demonstrated that parietal cortex stimulation in human subjects can result in deficits in spatial tasks(Bjoertomt et al., 2002), as well as in number comparison and time discrimination(Walsh &Pasual-Leone, 2003) ,in addition to the overlap in brain regions associated with time, space, and number in neuropsychology.

1.4 Predictions of the common magnitude system

One would also anticipate frequent interactions among amount representations if a single system were in charge of processing all quantity information. A common magnitude system suggests that a single mental unit represents temporal, numerical, and spatial magnitudes; as a result, representations of one quantity may be mistaken for representations of another, resulting in biassed responding (Meck & Church, 1983). Consequently, it would be possible that, for instance, information about spatial magnitude would interfere with and skew, for example, numerical judgments (referred to as quantity interference here). Exultantly, if quantitative data were converted into a common currency, one would anticipate that rules discovered in one quantitative domain would naturally generalize to the others (i.e., cross-domain transfer), leading to the mapping of one quantity onto another (for example, a number being mapped to space; cross-domain mapping).

The common magnitude account would likewise predict identical response biases in similar settings. Quantity processing in the actual world takes place in various scenarios, despite the fact that studies of quantity representation frequently occur in controlled lab settings. For instance, we might need to estimate how far a fast-moving car is from the crossing where we are standing or how long it will take the car to get at the crossroads. These real-world situations include emotional reactions or cognitive processing constraints that may impair our capacity to render precise numeric judgments. Notably, one would anticipate that these environmental elements would have the same impact on the amount of processing if the same mental magnitudes represented time, space, and number via a single system.

Specifically, similar brain activity patterns should be induced by temporal, numerical, and spatial processing, and finer-grained investigations at the cell level should also indicate a shared representational code. Relatedly, because quantity processing should be tied to a single neural locus, any impairments to this quantity processing system should,n addition to comparable behavioral patterns, a common magnitude system, presumably located at a common neural locus, predicts overlapping neural activation to occur during temporal, numerical, and spatial tasks. That is, temporal, numerical, and spatial processing should not only invoke identical brain activation patternsThe disruption of this quantity processing system should generate equivalent deficits in temporal, numerical, and spatial abilities since quantity processing should be connected to a single brain locus. Therefore, clinical examinations ought to point to similar deficiencies in quantity processing. Mainly, there should be very high comorbidity of problems with spatial, numerical, and temporal processing.

1.5 Mediating Role of Attention

The argument for ATOM up to this point is founded on the idea that the need to encode information about the external world's magnitudes that are employed in action serves as the primary function, or at the very least the connecting process, of the multiple abilities of the parietal cortex. In other words, the parietal cortex transformations, which are sometimes thought to compute "where" in space, instead respond to the action-related concerns of "how far, how quickly, how much, how long, and how many." This perspective differs from the notion that the parietal cortex's linking role is attention.

Regarding ATOM, It is proposed that attention is unlikely to add to the study of common mechanisms of magnitude and that in some studies in which attention has been used as a post-hoc justification for temporal processing,somebody maybe reinterpreted in light of common magnitude components in the tasks used. Suppose one takes into account standard behavioral timing models. In that case, all conceivable levels of the temporal process have thus far received attention: The switch is located at the pacemaker level,between the pacemaker and the accumulator, the accumulator, the storage or comparator, and the scheduled time.

Impairments in temporal processing caused by lowered attention have provided numerous explanations for the lengthening or shortening of experience time; attention is occasionally diverted.It is believed to be significant because time necessitates sustained or quick switching of attention between a short or long interval and is preferable for long intervals and at other times for short intervals . There is also minimal distinction regarding the precise function of attention: It might be the mediating factor of "attention."Attention can employ time in the "modulation of target-related neural activity"(Minniussi et al., 1999) or it may be mediated by the gate, which "mediates the effect of attention" (Casini &Macar, 1997). Finally, attentional explanations may also refer informally to attention to time, attention that has been refocused on time, or attention to motions. Every brain area that has been linked to attention in general, including the right and left, has been found to have temporal attention mechanisms.

According to(Droit-Volet et al., 2004), arousal modulation of the temporal estimation process leads to overestimating perceived duration. As an alternative,(Young & Cordes, 2013) contend that attentional focusing may affect numerical estimations, leading to increased attention to arousing stimuli and a concomitant failure to encode every enumerable visual display component, leading to numerical underestimation. Importantly, similar attention-based claims have been made for cognitive functions in response to emotional stimuli in domains like memory (MacKay &Ahmetzanov, 2005), Stroop color-naming (Siegrist, 1995; Williams et al., 1996), visual search (Hman& Esteves, 2001; Hman et al., 2001), and others.

According to (Shukla&Bapi, 2021), there might not be a need for a common magnitude processing system for that numerical magnitude and time. They partially duplicated the result and found that the numerical magnitude did not seem to alter the temporal experience when we looked at additional metrics of temporal processing. However, numerical magnitudes may cause temporal perception to distortand result in more accurate relative temporal evaluations. This comparable temporal experience could result from the automatic processing of numbers requiring diverse attentional mechanisms that become active with varying magnitudes.

Results from previous studies in which small and large numerical magnitudes presented in either a blocked or mixed condition appear to offer some evidence (Vicario, 2011). The magnitude of the numbers only affected temporal processing when they were presented in a mixed order in which the numbers were all randomly arranged in the same block encouraging a constant attentional shift along the internal left-to-right mental number line. According to the 'timeline' hypothesis, which holds that temporal intervals are coded within a left-to-right spatial representation (Vicario et al., 2007, 2009), like numerical representations (Dehaene et al., 1990), these attention shifts would then be accountable for the temporal biases discovered in the present research. (Telmach& Herdman, 1991) supportedthis assumption, showing that the allocation of attention influences the perception of temporal order. These effects have been linked to the differing attentional needs for processing the relative numerical magnitude. Thus, we suggest that the altered general attentional mechanisms involved in the automatic processing of numerical magnitude dimensions (or numbers) may cause the different temporal perceptions shown in our research.

In addition to the abovementioned experiments, a few more investigations have suggested that visuospatial attention plays a function in this cross-domain magnitude interaction. Number and time magnitudedisplayed in the left and right visual spaces to help researchers comprehend the process of visuospatial attention. Independent of numerical magnitude, authors reported temporal overestimation in the right visual space and underestimation in the left. However, only when the numbers were shown in the center did numerical magnitude bias temporal estimation(Vicario et al., 2008). As we previously demonstrated, the accuracy but not the precision of temporal judgments are selectively influenced by numerical magnitude. We hypothesized that this selection bias might be due to visuospatial attention.

1.6 Domain-specific processing

Others have argued that different modules are in charge of processing quantities, even though a shared system representing all or at least some amount representations during a portion of the life span has received much support. In other words, the notion that similar cognitive and brain regions track time, number, and space is challenged by the idea that time, number, and space are tracked by distinct cognitive and neural regions. For instance, some have proposed the approximation number system (ANS), which is supposed to be an intrinsic, domain-specific structure that enables the representation of a number (Dehaene, 1997; Dehaene, Dehaene-Lambertz, & Cohen, 1998; Odic & Starr, 2018). This system is intended to monitor numbers. Other researchers (Buhusi& Meck, 2009) have concentrated only on interval timing skillsor spatial abilities (Vasilyeva & Lourenco, 2012), considering these domains distinct.

(Proctor & Cho, 2006), for instance, have proposed the polarity correspondence principle, which postulates that when participants are given a binary classification task, they tend to categorize stimulus into two polarities because the job requires selecting one of two responses to each stimulus. The number-time interference effect seen in earlier investigations may result from congruent polarities of the temporal and numerical dimensions.

1.7 Evidence against common magnitude system

Recent research, however, has made a strong case against the notion of a common magnitude system and in favor of domain-specific processing. Participants in a recent study were assessed on numerosity and temporal judgements while performing a temporal bisection task(Hamamouche et al., 2018).They made numerical or temporal judgements while remembering letters. The authors proposed that even in the presence of cognitive load, number and time would still show same bias if a common magnitude processing were present.The outcome demonstrates that cognitive stress results in differing biases between the two magnitude domains. More specifically, in the mental load condition, participants overestimated duration in the temporal judgment task and underestimated numerosity in the numerosity task.

An adaptation model has also been used to study how numerosity and temporality interact(Tsouli& Dumoulin, 2019). It is assumed that, if number and time are processed through the same system of magnitudes, adaptation to numerosity will alter how duration is processed and that of duration with numerosity. Interestingly, the authors found that numerosity adaptation had a one-way impact on it, but not the other way around. A more recent study looked into how time is processed explicitly and implicitly in relation to numbers and vice versa. The large numerical magnitude matched with a long rather than a short duration. Participants processed information in explicit processing settings significantly faster and more accurately. However, no facilitation seen when the modest numerical magnitude was presented with short durations.

Additionally, participants' accuracy for long-duration judgments was somewhat higher after processing big numerical magnitudes as opposed to small numerical magnitudes. It's interesting to note that the reverse trend w seen for brief periods. According to some researchers, numerical information has a more significant impact on temporal processing than vice versa.

It has noted that the presentation of words with different lengths impacted duration assessments. In particular, the assessment of duration gets longer as the word length is longer. For instance, the word "train" appeared to stay on the screen longer than "pen." However, the time had no impact on spatial assessments of word length. This suggests that interactions between magnitudes lack a bidirectional influence.

These contradictory results raise the question of whether the magnitude information of the time and number domains is handled independently or by a single processing mechanism. This topic is still up for discussion and debate.

2 REVIEW OF LITERATURE

Since at least 1890, connections between time and number perception have been noticed, and other parallels between time and space or space and quantity also exist (Walsh &Pasual-Leone, 2003)

Recent investigations have shown that task-irrelevant numbers of flashing dots influenced responses in a temporal comparison task in sequences, numerical magnitudes encoded in stimuli (Oliveri et al., 2008; Vicario et al., 2008; Xuan, Zhang& Pesenti, 2006), and other factors and by magnitude data in non-numerical physical dimensions (Xuan et al., 2007). In these studies, they discovered that participants tended to say a stimulus was longer if it had a bigger task-irrelevant magnitude. This Strong evidence supports the idea that time and number processing are interdependent.

Through the use of temporal perception tests and stimuli related to various sensory inputs, numerous studies documented temporal illusions resulting from the physical amplitude of the stimulus. For example, temporal overestimations, a function of stimulus magnitude, have been demonstrated by non-temporal stimulus characteristics such as stimulus size (Rammsayer& Verner, 2014; Xuan et al., 2007), auditory loudness (Matthews et al., 2011), stimuli velocity (Makin et al., 2012), visual contrast (Benton & Redfern, 2016), stimulus regularity (Sasaki & Yamada, 2017), or flicker frequency (Herbst et al., 2013) in the visual and auditory domains.

In addition to highlighting the significance of the magnitude effect, Ono and Kawahara found altered perceived time of an Ebbinghaus illusionary-size-varied item. Their findings demonstrated that the perceived duration for stimuli that appeared to be larger was longer than that for stimuli that seemed smaller (Ono & Kawahara, 2007). A bidirectionality effect also discovered, where longer perceived stimuli were relatively larger. Subjective temporal perception is influenced by non-temporal factors such as the amplitude of the physical and perceptual input.

As previously shown, Arabic digits affect time bisection so that durations tend to be underestimated for low numbers and overstated for big numbers (Oliveri et al. 2008; Vicario et al., 2008; Lu et al. 2009). The substantial results of both numerical and numerical magnitude*temporal block interaction consistently illustrate this effect. The underestimate of temporal intervals following a small number and the overestimation of temporal intervals following a big number was only present for the suprasecond circumstances, indicating that the interaction determines the significant influence of numerical magnitude.

Between sub-second and supra-second durations, various temporal processing mechanisms apply.Timing of sub-second intervals is thought to be a relatively automatic process and beyond the control of the brain, despite the need of memory systems such as working memory for processing supra-second intervals.

(Lewis & Miall, 2003) used Functional imaging to compare sub- and supra-second time in the human brain directly. These motor regions are more involved in measuring small intervals, even during non-motor time, based on the discovery that the cerebellum and frontal operculum are more active during measurement 0.6 than 3 s. They observed that increased attentional demands of this assessment may be related to the observed larger parietal activity during the 3 s gap.The results suggested a common timing system for sub- and supra-second time measurements and extra parts for timing short and long intervals.

The subjective duration of a given interval generally correlates positively with stimulus magnitude (the "more is longer" account), but it is equally important to note that the relative, rather than the absolute, magnitude of the stimulus affects this subjective duration (Gomez & Robertson, 1979; Matthews & Meck, 2016). (Gomez & Robertson, 1979) demonstrated that when contrasted to small items, a large visual stimulus is seen as being longer, but only when object size varied within the session, and participants could openly compare their sizes. This may be because the magnitude of perceptual representations depends on the interaction of internal processing and external stimulus. The distribution of processing power, memory, and even mental effort are viewed as internal processing. These interactions determine The final perceptual clarity, which explains how greater stimulus intensity may cause an exaggeration of subjective time perception.

More recently, Xuan et al. examined whether magnitude information in different dimensions, such as space, quantity, and time, modulates duration judgments (Xuan et al., 2007). Participants in a Stroop-like interference wanted to determine which of two continuous stimuli had a longer duration. According to the findings, temporal accuracy was higher when, in different temporal tasks, luminance intensity and the length to be evaluated were the same or when the shorter stimulus was dark and the longer stimulus was bright. Importantly, this congruency effect was discovered across various magnitudes (e.g., number of dots, size of a square), suggesting that magnitude representations contain generalized and abstract components.

In a number of their tests, Matthews and Stewart varied the luminance of the target and background stimuli. Surprisingly, the background impacts the effect of stimulus magnitude on temporal perception: bright stimuli on dark backgrounds and dim stimuli against high-intensity backgrounds were both perceived as lasting longer (Matthews et al., 2011). This latest research suggests the potential that the interaction between the intensity of external stimuli and internal cognitive processing may also affect how brightness magnitude is represented perceptually, modulating temporal perception.

However, the magnitudes connected to time and number are processed through different mechanisms, according to more recent studies that supported the notion of domain-specific magnitude processing.Recent research, however, has made a strong case against the idea of a common magnitude system and favoring domain-specific processing. Participants in a recent study assessed numerosity and temporal judgments while performing a temporal bisection task.They made numerical or temporal judgments while remembering letters. The authors proposed that even in the presence of cognitive load, number and time would still show biases if a common magnitude processing were present. The outcome demonstrates that cognitive stress results in differing biases between the two magnitude domains. More particular, under the cognitive load condition, participants overestimated the length of the temporal judgement task while underestimating numerosity (Hamamouche et al., 2018).

Contrary to the well-known "magnitude effect," the perceived duration of the stimuli that appeared to be brighter (glare stimuli; greater pupillary light reflex) was shorter than that of the control stimuli (halo stimuli; smaller pupillary light reflex). Additionally, when they altered physical luminance of the stimuli was altered to match the illusory-induced magnitude, this temporal modulation did not occur. These findings suggest that the confluence of external and perceived subjective magnitude is necessary for temporal processing and that even illusory brightness is sufficient to affect the perception of duration. This finding may be explained by the internal magnitude decrease of glare stimuli caused by pupillary constriction, which lowers the amount of light entering the eye(Xuan et al. 2008)

(DeWind & Brannon's, 2012) findings run counter to ATOM, which asserts that strengthening one quantitative domain (such as a number) will support others (such as space). DeWind and Brannon (2012) conducted specific numerical training in this area, reporting improved numerical abilities but not in a spatial problem. This lack of transfer effects makes it impossible to train just one domain and expect to see benefits in the untrained area. Improving the relationship between numbers and space is the target of interventions that are thought to be more advantageous for fundamental geometrical and numerical knowledge (Cipora et al., 2015; Hawes et al., 2017).

Timing theories based on clocks, such as the Scalar Expectancy Theory (SET), contend that a built-in mechanism for keeping track of time is used to process temporal information. This clock-like device (pacemaker/timer) generates pulses at a predetermined rate, which are then added to an accumulator after passing via a switch (Gibbon, 1977; Gibbon et al., 1984). When it is appropriate to encode the duration of an event, the accumulation is moved to a short-term memory store and, depending on the environment, to long-term memory storage. When accumulated stores and representations in long-term memory are compared, decisions made regarding the temporal information.

The same results observed when a person is aroused through emotional signals. In the (Watts & Sharrock, 1984) investigation, participants with phobias were directed to see images of phobic stimuli during encoding and subsequently provide temporal estimates of the exposure period. Phobic respondents underestimated the length of the pictures more than non-phobic participants did, consistent with a spike in clock speed while encoding the size of the scary stimuli. All of these findings support the idea that arousal brought on by emotional triggers accelerates clock speed. (Langer et al., 1961) found that people underestimated an interval's length when fearful, which is congruent with a rise in clock speed during reproductions.

In more recent research, (Droit-Volet et al., 2004) showed that estimates of the length of emotional faces were longer as encoding arousal levels rose. All of these findings support the idea that arousal brought on by emotional inputs accelerates clock speed.

Because attentional resources are finite and must be divided between timing and non-timing activities, attention also affects how people perceive time (Brown, 1997, 2008; Macar et al., 1994; Penney et al., 2000; Zakay & Block, 1997). According to the attentional allocation paradigm (Penney et al., 2000; Zakay & Block, 1997), paying attention to time modifies the SET's accumulating pulses. Shorter encoded durations result from fewer pulses accumulating when time is diverted during encoding. The slower accumulation of pulses causes it to take longer to attain a criteriaanumber of pulses, and estimates are longer when attention is diverted during the reproduction of a previously learned period (Macar et al., 1994; Penney et al., 2000).

When arousal was low, (Angrilli et al., 1997) hypothesized that the lengthier estimates of positive than negative images might be due to the negative pictures diverting attention from timing during encoding, resulting in shorter estimates.

(Shukla&Bapi, 2022) The hypothesis of number-time interaction was tested in cross-modal contexts, and the findings imply that visual numbers may only influence duration judgments of tone when they are available at the time of temporal judgment. Compared the large numerical magnitude with the small numerical magnitude displayed in the visual domain, the tone duration was vastly overstated in the case of large numerical magnitude

Because of the numerical and temporal information presented in two different modalities, these pieces of magnitude information must be available simultaneously for any interaction. Working memory may be where such data integration occurs. Attentional mechanisms may serve as a gatekeeper, keeping task-irrelevant numerical information out of the working memory where the temporal processing is already underway. Therefore, a similar magnitude processing system operating across sensory modalities may not be necessary for the influence of visual numbers on the temporal processing of tone.

Numerous research on timing has demonstrated that faster rhythms produce longer time estimates than slower rhythms using specific click sequences (Treisman et al., 1990, 1992; Penton-Voak et al., 1996; Droit-Volet & Wearden, 2002; Ortega & López, 2008). The various authors contend that these findings might be explained by an increase in arousal caused by the click sequence, which causes the internal clock to tick more quickly.

According to (Droit-Volet & Meck, 2007), increased arousal in response to emotional stimuli is linked to a speed-up internal clock, leading to a longer perception of time. The arousal dimension of emotional stimuli correlates to a subjective state ranging from calm-relaxed to excited-stimulated, according to psychophysiological investigations using standardized emotional material (Greenwald et al., 1989; Lang et al., 1999). According to (Juslin&Västfjäl, 2008), an increase in arousal level is indeed linked to physiological activation of the autonomic nervous system.

(Noulhiane et al., 2007) reached the same conclusion as the majority of studies on the connection between time and emotion, stating that "physiological activation is the predominant aspect of the influence of emotions on time perception, as all emotional stimuli regardless of their self-assessed valence are perceived as being longer than neutral ones" In addition, he noted that when compared to physiological activation, the emotional valence of noises had little impact on how people perceive time.

The lengthening effect brought on by arousal/tempo is likely the result of the internal clock automatically speeding up. On the other hand, the valence effect (pleasant vs. unpleasant) may activate controlled attentional mechanisms that are connected to the sense of pleasure felt while listening to melodic music.

3 RESEARCH GAP

Human cognition has always been fundamentally based on how we process time and numbers. A theory of magnitude (ATOM), one of the most well-known theories of magnitude processing, postulates that a generalized magnitude system processes space, time, and numbers; hence, the magnitude dimensions may possibly interact.One of ATOM's hypotheses is that there will be a monotonic mapping between different magnitude systems, i.e., the smaller magnitude in one domain (for example, a shorter duration) will be correlated with the smaller magnitude in another domain (for example, a smaller number), and vice versa for larger magnitudes. Numerous behavioral and neuroimaging studies conducted over the past 20 years have gathered evidence in support of a generalized magnitude system and argued that a common magnitude system exists . However, the magnitudes connected to time and number are processed through different mechanisms, according to more recent research that showed evidence in favor of domain-specific magnitude processing. Recent studies, however, have made a strong case against the notion of a common magnitude system and in favor of domain-specific processing. Due to the contradictory results, it is unclear whether these magnitudes are processed individually or through a single processing mechanism. As the Theory claims, duration and number are closely related, but what is their exact relationship? Do these two represent a common magnitude system or a domain-specific processing system? Is there any interaction between these two domains or not? Through our research, we strive to find answers to all these crucial questions. Let's suppose that the conventional metric system does not process space, time, and numbers. In that situation, we must offer a different explanation for the findings from the body of existing research that support ATOM. In the current study, we looked at whether a common processing mechanism or cognitive elements are responsible for the influence of one magnitude on the processing of the other magnitude. Here, we focus on how task-unrelated numerical magnitude affects temporal perception.

To inspect the above objective, we experimented using a temporal bisection task in which a task-irrelevant numerical magnitude was presented in two colors, red and gray for varied durations. Participants were supposed to judge the duration of the number whether the presented duration was closer to short or closer to long anchor duration. If they felt the presented duration to be closer to the short anchor duration, they would press the left arrow and press the right arrow if they felt it to be more closer to long anchor duration which they memorized in training phase.We hypothesize that if altered attentional mechanisms are engaged in number –time interaction, then there will be overestimation of duration judgment for large numerical magnitude presented in red color as compared to small numerical magnitude in red color whereas we expect no such differences for numerical magnitude in gray color.

4 Method

4.1 Sample:

The current study included a total number of 33 female participants of the age group 18-25 years from Thapar Institute of Engineering & Technology, Patiala. The sample for the study waschosen using convenience sampling. Participants had normal vision, and they all were naive to our experimental hypothesis

4.2 Tools Used:

On a 17″ CRT monitors running at a frame rate of 100 Hz, the stimuli were displayed and controlled using Open Sesame stimulus presentation software.

4.3 Stimulus:

The testing phase began with the fixation dot presented at the center of the monitor. Whenever the subject was ready they were asked to press the spacebar to begin the trial. On screen the numbers "one" and "nine" were presented in either red or gray color against the white background. These numbers were presented in an intermixed fashion with varying durations. The participants were asked to judge the duration of each stimulus presented. The durations for each number ranged from 200 ms to 800 ms. If they felt that thenumber presented was closer to short anchor duration they were supposed to press the "left arrow" on the keyboard. Similary if they felt that the number presented was closer to long anchor duration they were required to press the "right arrow" .

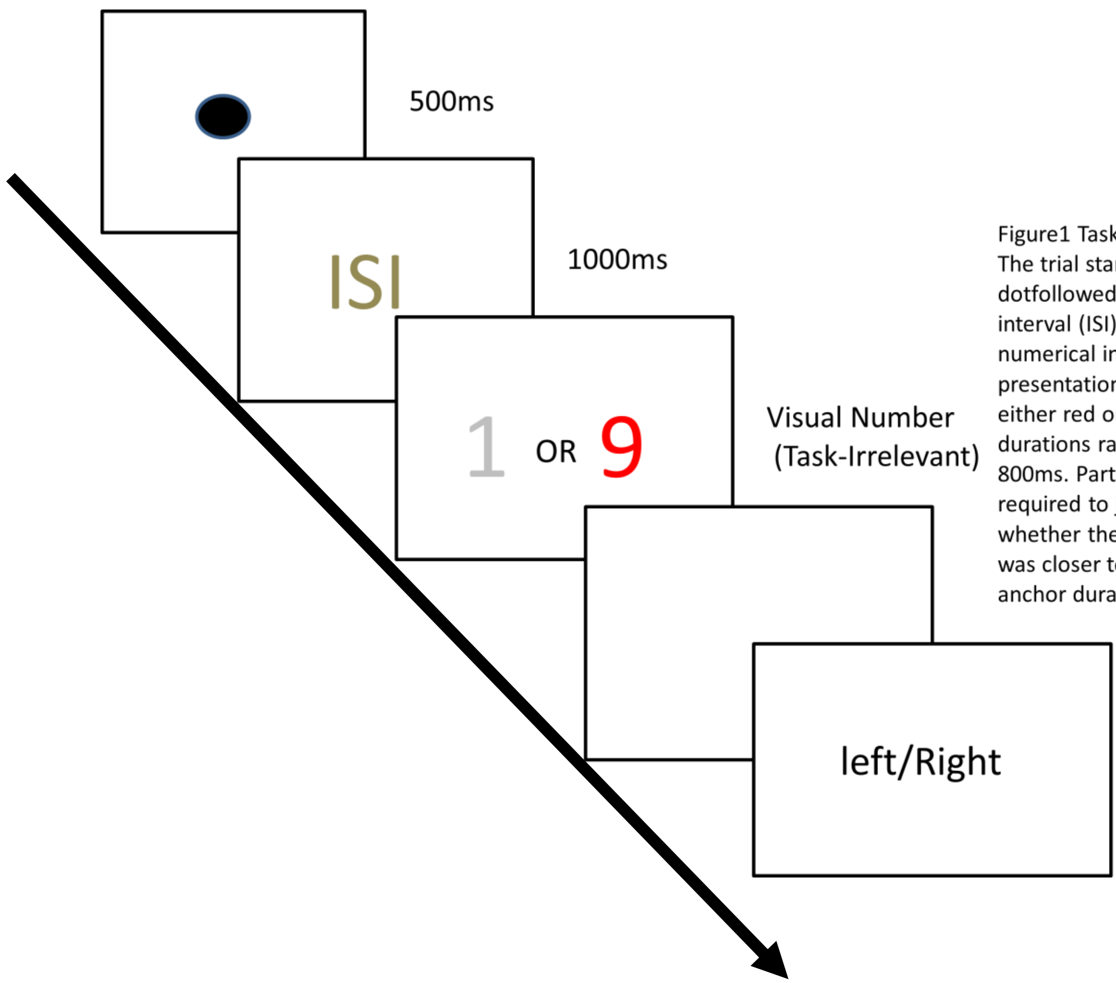

Figure1 Task illustration
The trial started with a fixation dotfollowed by the inter stimulus interval (ISI). After the ISI, the numerical information was presentation stimuli 1 or9 in either red or gray color for durations ranging from 200-800ms. Participants were required to judge the duration whether the stimuli presented was closer to long or short anchor duration

4.4 DESIGN

For the purpose of this study, we used a within-subject design in which each participant was exposed to all the different durations

4.5 Procedure:

In order to carry out the experiment a sample of 33 students was chosen from Thapar Institute of Engineering and Technology, Patiala. With their due consent, the participants were made to sit comfortably in a dimly lit room. After establishing a good rapport with the participants, they were initially trained before conducting the main experiment. In the training phase they were made to observe short and long duration, followed by a feedback phase where they were asked to identify whether the presented duration was longer or shorter and the system provided feedback on whether the response was correct or incorrect.Participants were given 10 trials of short anchor durations and 10 trials of long anchor durations, coupled with the number "5" on the computer screen, to help them understand the long and short durations. We ensured participants completed the duration judgment task with 90% accuracy throughout this stage. The participants were then moved on to the testing step once they met this performance criterion.. In this phase the participants were shown numbers of different magnitudes,i.e small "1" and large "9" in two different colors i.e. "red" and "gray" of varying durations from 200-800ms in steps of 100. The durations used in the actual experiment were different from those used in the trial phase. Similar to the training phase, participants were supposed to press "right arrow" if they estimated the duration to be closer to long anchor duration and "Left arrow" if they estimated the duration to be closer to short anchor duration they memorized in the training phase. The experiment consisted of 196trials[2 (Number: 1 and 9) × 2 (Colors : Red and Gray) × 7 (Durations: 100 to 800 ms) × 7 (Repetitions)].

5 RESULTS

We estimated a bisection point (BP) for each numerical magnitude condition. The BP is the point at which participants would have thought the presented duration was more similar to the short anchor duration 50% of the time and more similar to the long anchor duration 50% of the time. The BP is also known as the point of subjective equality (PSE), thus from this point forward, we'll refer to it as PSE. PSE estimations are smaller when the psychometric curve is shifted to the left than they are when it is shifted to the right. In addition, a bigger PSE would be seen as underestimating duration, whereas a smaller PSE would be seen as overestimating time.

We employed a 2 (Magnitude: Small and Large) × 2(Color:Red and Gray) repeated measures ANOVA to assess the influence of attention on number-time interaction.

TABLE NO.1 - DESCRIPTIVE STATISTICS

	PSE_G1	PSE_G9	PSE_R1	PSE_R9
Valid	33	33	33	33
Missing	0	0	0	0
Mean(in sec)	0.56	0.54	0.57	0.53
St. Deviation	0.05	0.06	0.07	0.06
Minimum	0.39	0.38	0.40	0.38
Maximum	0.63	0.65	0.75	0.66

The above table no - 1 represents the total number of participants (n=33) and their corresponding mean and standard deviation scores.

TABLE NO.2 - REPEATED MEASURES ANOVA

Cases	Sum of Squares	Df	Mean Square	F	P	η_p^2
Color	4.536×10^{-6}	1	4.536×10^{-6}	0.004	0.953	1.118×10^{-4}
Residuals	0.041	32	0.001			
Magnitude	0.028	1	0.028	35.678	< .001	0.527
Residuals	0.025	32	7.744×10^{-4}			
Color x Magnitude	0.004	1	0.004	5.609	0.024	0.149
Residuals	0.023	32	7.188×10^{-4}			

Table no.2shows a significant main effect of magnitude , $F(1,32)=35.678$, $p<.001$, $\eta_p^2=0.527$ which suggests that there is a overestimation of duration judgement in case of large numerical magnitude and underestimation of duration judgement in case of small numerical magnitude which is consistent with the ATOM theory.

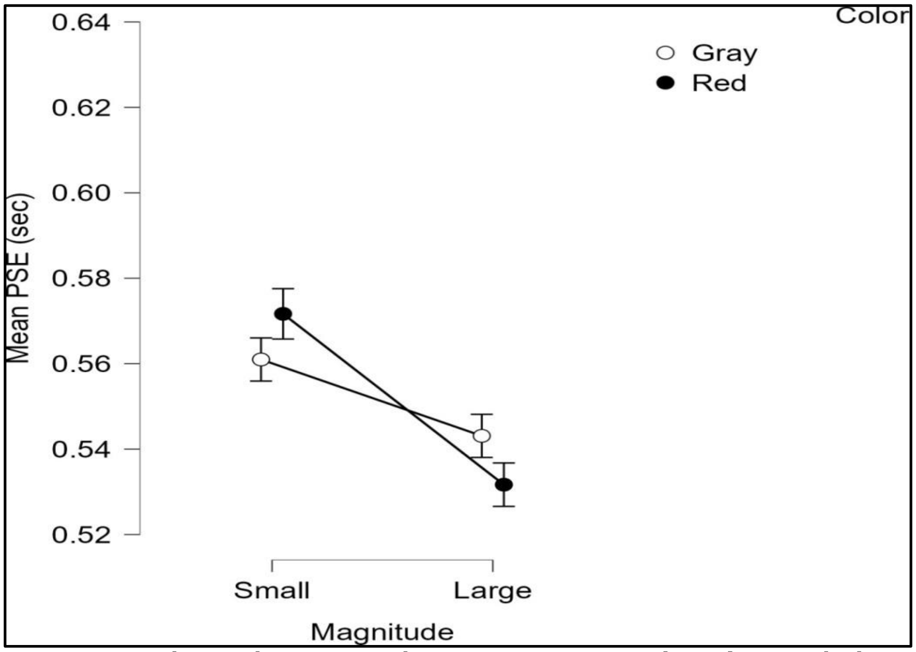

Figure- 1The graph represents the mean PSE across task conditions. The line with black dots represents numerical magnitude of red color and the line with white dots represents numerical magnitude of gray color.

The above figure represents a smaller PSE for large numerical magnitude presented in red color, which indicates overestimation of perceived duration, and large PSE for small numerical magnitude presented in red color, which indicates an underestimation of perceived duration.

TABLE NO.4 -POST HOC COMPARISON (COLOR* MAGNITUDE)

		Mean Difference	SE	T	P_{bonf}
Gray, Small	Red, Small	−0.011	0.008	−1.377	1.000
	Gray, Large	0.018	0.007	2.658	0.059
	Red, Large	0.029	0.008	3.726	0.003**
Red, Small	Gray, Large	0.029	0.008	3.631	0.003**
	Red, Large	0.040	0.007	5.945	< .001***
Gray,Large	Red,Large	0.011	0.008	1.473	0.877

** p<.05, **p< .01,***p< .001Note.P-valueadjustedforcomparingafamilyof6*

The table represents highly significant color*Magnitude interaction effect in case of large and small numerical presented in red color .

TABLE NO.5 -REPEATED MEASURE ANOVA

Within Subjects Effects					
Cases	Sum of Squares	Df	Mean Square	F	P
PSE	0.032	3	0.011	11.470	< .001
Residuals	0.088	96	9.202×10^{-4}		

Note. Type III Sum of Squares

6. DISCUSSIONS

In the present study we wish to investigate how the task-irrelevant numerical magnitudes impact the perception of time using a temporal bisection task. Several studies support the ATOM's proposition of a common magnitude system leading to number time interaction in the temporal discrimination task.(Xuan et al., 2007; Srinivasan & Carey, 2010; Cai & Connell, 2015; Schwiedrzik et al., 2016; Yamamoto et al., 2016). (Meck & Church, 1983) were the first to propose that a single, shared cognitive system (the analogue magnitude system, or AMS), situated within a particular neural locus, was in charge of processing time and number through experiments in which rats were able to generalise rules in one domain (e.g., time) to another domain (e.g., number). (Walsh, 2003) proposed an extension of this Theory, the Theory of magnitude (ATOM), which asserts that time, space, and number are each represented by a shared magnitude system in which a common metric for action particularly connects quantities. (Walsh, 2003) contends that sensorimotor activities are facilitated by processing quantities through a single system. On the contrary, many studies found substantial evidence against the existence of and need for a generalized magnitude system (Agrillo et al., 2010; Young & Cordes, 2013; Hamamouche et al., 2018). Participants in a recent study assessed on numerosity and temporal judgements while performing a temporal bisection task(Hamamouche& Keefe, 2018).They made numerical or temporal judgements while remembering letters. The authors proposed that even in the presence of cognitive load, number and time would still show same bias if a common magnitude processing were present.The outcome demonstrates that cognitive stress results in differing biases between the two magnitude domains. More specifically, in the cognitive load condition, participants overestimated duration in the temporal judgment task and underestimated numerosity in the numerosity task.

As the Atom theory claims, duration and number are closely related, but what is their exact relationship? Do these two really represent a common magnitude system or a domain-specific processing system? Is there any interaction between these two domains or not? Through our research, we strive to find answers to all these crucial questions. In order to investigate this the participants were initially trained before conducting the main experiment. In the training phase they were made to observe short and long duration followed by a feedback phase where they were asked to identify whether the presented duration was longer or shorter, and the system provided feedback on whether the response was correct or incorrect.Participants were given 10 trials of short anchor durations and 10 trials of long anchor durations, coupled with the number "5" on the computer screen, to help them understand the long and short durations. We made sure that participants completed the duration judgement task with 90% accuracy throughout this stage. The participants were then moved on to the testing step once they met this performance criterion... In this phase the participants were shown numbers of different magnitudes, i.e., small "1" and large "9" in two different colors i.e.,"red" and "gray" of varying durations from 200-800ms in steps of 100. The durations used in the actual experiment were different from those used in the trial phase. Similar to the training phase the participants were supposed to press "right arrow" if they estimated the duration to be more closer to long anchor duration and "Left arrow" if they estimated the duration to be more closer to short anchor duration, they memorized in the training phase. The experiment consisted of 196 trials.

We hypothesize that if altered attentional mechanisms are engaged in number–time interaction, then there will be overestimation of perceived duration for large numerical magnitude presented in red color as compared to small numerical magnitude in red color whereas we expect no differences for numerical magnitude in gray color. Our results demonstrate that our judgment might be influenced by numerical magnitude as suggested by ATOM as the repeated measure Anova-type statistic revealed a main effect of magnitude on duration judgment. Further, the post hoc test suggested that significant color * magnitude interaction for large and small numerical magnitude presented in red color. The difference in temporal perception may result from altered general attentional mechanisms engaged in automatically processing numerical magnitude dimensions (or numbers). As depicted in Figure 1, PSE for large numerical magnitude in RED was smaller as compared to small numerical magnitude in red color.

PSE is the point at which participants would have thought the presented duration was more similar to the short anchor duration 50% of the time and more similar to the long anchor duration 50% of the time. PSE estimations are smaller when the psychometric curve is shifted to the left than they are when it is shifted to the right. In addition, a bigger PSE would be seen as underestimating duration, whereas a smaller PSE would be seen as overestimating time.

Thus there was overestimation of duration judgement for LARGE numerical magnitude presented in RED color as compared to SMALL numerical magnitude in RED . The temporal duration was overrestimated in case of large numerical magnitude presented in red color due to the interference of attentional mechanisms as red color is more arousing as compared to gray so the participants oversestimated the temporal duration in case of large numerical magnitude presented in red color as compared to small numerical magnitude in red but no such effect was seen in case of gray numerical magnitude as there was no such arousal in case of gray color . (Briki& Hue, 2016) investigated how red and dominance are related. Participants in the study were asked to rate the prominence, arousal, and pleasure of a colour (either red, blue, or green) while it appeared on a computer screen. Their findings demonstrated a high correlation between red and dominance and arousal, a correlation between green and arousal, and a rating of blue and green as being more pleasing than red.As has been observed in animals (Cuthill et al., 1997; Pryke et al., 2007; Pryke, 2009), this implicit red-dominance link may cause emotionality to change, producing a dominant behavioural and physiological response (Hill & Barton, 2005).

(Noulhiane et al., 2007) reached the same conclusion as the majority of studies on the connection between time and emotion, stating that "physiological activation is the predominant aspect of the influence of emotions on time perception, as all emotional stimuli regardless of their self-assessed valence are perceived as being longer than neutral ones"

According to (Droit-Volet & Meck, 2007), increased arousal in response to emotional stimuli is linked to a speed-up internal clock, leading to a longer perception of time. The arousal dimension of emotional stimuli correlates to a subjective state ranging from calm-relaxed to excited-stimulated, according to psychophysiological investigations using standardized emotional material (Greenwald et al., 1989; Lang et al., 1999). According to (Juslin&Västfjäl, 2008), an increase in arousal level is indeed linked to physiological activation of the autonomic nervous system.

According to(Droit-Volet et al., 2004), arousal modulation of the temporal estimation process leads to overestimating perceived duration.

(Shukla&Bapi, 2022) The hypothesis of number-time interaction was tested in cross-modal contexts, and the findings imply that visual numbers may only influence duration judgments of tone when they are available at the time of temporal judgment. Compared the large numerical magnitude with the small numerical magnitude displayed in the visual domain, the tone duration was vastly overstated in the case of large numerical magnitude

Because of the numerical and temporal information presented in two different modalities, these pieces of magnitude information must be available simultaneously for any interaction. Working memory may be where such data integration occurs. Attentional mechanisms may serve as a gatekeeper, keeping task-irrelevant numerical information out of the working memory where the temporal processing is already underway. Therefore, a similar magnitude processing system operating across sensory modalities may not be necessary for the influence of visual numbers on the temporal processing of tone.

Our experimental data indicate that attentional mechanisms might bias our temporal judgments.As show in table no. 6 we also saw Color ×Magnitude interaction which came out to be significant in case of the large and small numerical magnitude presented in red color.The additional analysis supports that numerical magnitude may not directly affect temporal processing but could influence via attentional mechanisms. This automatic processing of numbers needing different attentional mechanisms that become active with various numerical magnitudes may cause this relative temporal experience. The differential attentional demands for processing the relative numerical magnitude have been linked to these effects. As a result, we propose that the difference temporal perception seen in our study may possibly be a result of altered general attentional mechanisms like arousal that are engaged in the automatic processing of numerical magnitude dimension (or numbers).

7 CONCLUSION

In the present study, we examinedthe influence of attentional mechanisms on temporal perception which is inconsistent with the ATOM theory.The findings indicate that a common magnitude system may not be able to explain the number time interaction. This interaction effect may be better explained by decision-making processes, attentional and cognitive demands caused by uncertainty in duration processing. Thus, we can infer that there is a domain specific processing system for numerical and temporal information. . In future, increasing the sample size and including certain other variables relevant to alter attention as well as temporal perception could be a good place to carry forward this body of research

REFERENCES

- Andres, M., Davare, M., Pesenti, M., Olivier, E., & Seron, X. (2004). Number magnitude and grip aperture interaction. *PubMed*, *15*(18), 2773–2777. https://pubmed.ncbi.nlm.nih.gov/15597052

- Andres, M., Olivier, E., &Badets, A. (2008). Actions, Words, and Numbers. *Current Directions in Psychological Science*, *17*(5), 313–317. https://doi.org/10.1111/j.1467-8721.2008.00597.x

- Andres, M., Ostry, D. J., Nicol, F., & Paus, T. (2008). Time course of number magnitude interference during grasping. *Cortex*, *44*(4), 414–419. https://doi.org/10.1016/j.cortex.2007.08.007

- Angrilli, A., Cherubini, P., Pavese, A., & Manfredini, S. (1997). The influence of affective factors on time perception. *Attention Perception & Psychophysics*, *59*(6), 972–982. https://doi.org/10.3758/bf03205512

- Benton, C. B., & Redfern, A. S. (2016). Perceived Duration Increases with Contrast, but Only a Little. *Frontiers in Psychology*, *7*. https://doi.org/10.3389/fpsyg.2016.01950

- Brannon, E. M., Suanda, S. H., & Libertus, K. (2007). Temporal discrimination increases in precision over development and parallels the development of numerosity discrimination. *Developmental Science*, *10*(6), 770–777. https://doi.org/10.1111/j.1467-7687.2007.00635.x

- Briki, W., & Hue, O. (2016). How Red, Blue, and Green are Affectively Judged. *Applied Cognitive Psychology*. https://doi.org/10.1002/acp.3206

- Brown, S. D. (1997). Attentional resources in timing: Interference effects in concurrent temporal and nontemporal working memory tasks. *Attention Perception & Psychophysics*, *59*(7), 1118–1140. https://doi.org/10.3758/bf03205526

- Bueti, D., & Walsh, V. (2009). The parietal cortex and the representation of time, space, number and other magnitudes. *Philosophical Transactions of the Royal Society B*, *364*(1525), 1831–1840. https://doi.org/10.1098/rstb.2009.0028

- Fischer, M. R., Castel, A. D., Dodd, M. D., & Pratt, J. (2003). Perceiving numbers causes spatial shifts of attention. *Nature Neuroscience*, *6*(6), 555–556. https://doi.org/10.1038/nn1066

- Hamamouche, K., Keefe, M., Jordan, K. E., & Cordes, S. (2018). Cognitive Load Affects Numerical and Temporal Judgments in Distinct Ways. *Frontiers in Psychology*, *9*. https://doi.org/10.3389/fpsyg.2018.01783

- Herbst, S. K., Javadi, A., Van Der Meer, E., & Busch, N. A. (2013). How Long Depends on How Fast—Perceived Flicker Dilates Subjective Duration. *PLOS ONE, 8*(10), e76074. https://doi.org/10.1371/journal.pone.0076074

- Hill, R. T., & Barton, R. A. (2005). Psychology: red enhances human performance in contests. *Nature*, *435*(7040), 293. https://doi.org/10.1038/435293a

- Kadosh, R. C., Kadosh, K. C., Linden, D. E. J., Gevers, W., Berger, A., & Henik, A. (2007). The Brain Locus of Interaction between Number and Size: A Combined Functional Magnetic Resonance Imaging and Event-related Potential Study. *Journal of Cognitive Neuroscience*, *19*(6), 957–970. https://doi.org/10.1162/jocn.2007.19.6.957

- Lindemann, O., Abolafia, J. M., Girardi, G., & Bekkering, H. (2007). Getting a grip on numbers: Numerical magnitude priming in object grasping. *Journal of Experimental Psychology: Human Perception and Performance*, *33*(6), 1400–1409. https://doi.org/10.1037/0096-1523.33.6.1400

- Makin, A. D. J., Poliakoff, E., Dillon, J., Perrin, A., Mullet, T., & Jones, L. A. (2012). The interaction between duration, velocity and repetitive auditory stimulation. *Acta Psychologica*, *139*(3), 524–531. https://doi.org/10.1016/j.actpsy.2012.01.013

- Matthews, W. J., Stewart, N., & Wearden, J. H. (2011). Stimulus intensity and the perception of duration. *Journal of Experimental Psychology: Human Perception and Performance*, *37*(1), 303–313. https://doi.org/10.1037/a0019961

- Oliveri, M., Vicario, C. M., Salerno, S., Koch, G., Turriziani, P., Mangano, R., Chillemi, G., & Caltagirone, C. (2008). Perceiving numbers alters time perception. *Neuroscience Letters*, *438*(3), 308–311. https://doi.org/10.1016/j.neulet.2008.04.051

- Rich, A. N., Chang, E. C., Tzeng, O. J., & Wu, D. H. (2009). The common magnitude code underlying numerical and size processing for action but not for perception. *Experimental Brain Research*. https://doi.org/10.1007/s00221-009-1730-8

- Schwiedrzik, C. M., Bernstein, B., & Melloni, L. (2016). Motion along the mental number line reveals shared representations for numerosity and space. *eLife*, *5*. https://doi.org/10.7554/elife.10806

- Shukla, A., &Bapi, R. S. (2021). Numerical Magnitude Affects Accuracy but Not Precision of Temporal Judgments. *Frontiers in Human Neuroscience*, *14*. https://doi.org/10.3389/fnhum.2020.629702

- Skagerlund, K., Karlsson, T., &Träff, U. (2016). Magnitude Processing in the Brain: An fMRI Study of Time, Space, and Numerosity as a Shared Cortical System. *Frontiers in Human Neuroscience*, *10*. https://doi.org/10.3389/fnhum.2016.00500

- Smets, G. J. F. (1969). Time Expression of Red and Blue. *Perceptual and Motor Skills*, *29*(2), 511–514. https://doi.org/10.2466/pms.1969.29.2.511

- Vicario, C. M., Pecoraro, P., Turriziani, P., Koch, G., Caltagirone, C., & Oliveri, M. (2008). Relativistic Compression and Expansion of Experiential Time in the Left and Right Space. *PLOS ONE*, *3*(3), e1716. https://doi.org/10.1371/journal.pone.0001716

- Walsh, V. (2003). A theory of magnitude: common cortical metrics of time, space and quantity. *Trends in Cognitive Sciences*, *7*(11), 483–488. https://doi.org/10.1016/j.tics.2003.09.002

- Xuan, B., Zhang, D., He, S., & Chen, X. (2007). Larger stimuli are judged to last longer. *Journal of Vision*, *7*(10), 2. https://doi.org/10.1167/7.10.2

- Yamamoto, K., Sasaki, K., & Watanabe, K. (2016). The number–time interaction depends on relative magnitude in the suprasecond range. *Cognitive Processing*, *17*(1), 59–65. https://doi.org/10.1007/s10339-015-0744-3

Appendices

Appendix A – Informed Consent Form

The purpose of this experiment is to study the effect of Attention in Number-Time Interaction. As a part of the experiment, you will be presented with small and large numerical magnitude on the screen Your job is to press the assigned key as per instructions that will appear on the screen before the commencement of the experiment.

- *Participation in the experiment is completely voluntary.*
- *Data will be kept confidential and subject's identity will be protected.*
- *Subject's participation will take approximately10-15 minutes.*
- *If you are still interested to participate and assist in the research project, please complete the consent form below. Thank you very much for your time and consideration*

Subject's Demographic details

- *Name of the participant*
- *Age*
- *Gender*
- *Education*
- *Contact Number*

By agreeing to this statement, you indicate that you understand the nature of the study and your role in the research and that you agree to participate in the experiment.

Appendix -B   Introductory Information about thetrainingphase.

Appendix C- Instructions

Separate instructions for the feedback phase and main experiment were given.

Instructions for the feedback phase

This is a feedback phase

In this phase you would be presented with the number 5 with long and short duration in random order. Your job is to identify whether the present durations were longer or shorter (based on learned duration from the training phase) and press the dedicated key “Left Arrow ” for short and “Right Arrow” for long. In this phase ,you will be given feedback on your response.

You have to maintain 100% accuracy in this section.

Once ready press spacebar to start

Instructions for the main experiment

This is the main experiment

In this phase you would be presented with the number 1 or 9 with long and short duration in random order. Your job is to identify whether the present durations were longer or shorter (based on learned duration from the training phase) and press the dedicated key “Left Arrow ” for short and “Right Arrow” for long. In this phase ,you will be given feedback on your response.

Clarify your doubts before proceeding.

Once ready press spacebar to start

TABLE NO. 6 – POST HOC COMPARISON - PSE

		Mean Difference	SE	T	p_{bonf}
G-1	G-9	0.018	0.007	2.394	0.112
	R-1	−0.011	0.007	−1.431	0.935
	R-9	0.029	0.007	3.924	< .001***
G-9	R-1	−0.029	0.007	−3.825	0.001**
	R-9	0.011	0.007	1.530	0.776
R-1	R-9	0.040	0.007	5.355	< .001***