Craig E. Geis
California Training Institute
cegeis@aol.com

Factors Affecting Reaction Time
Scientific Journal Reviews

Reviewing journal articles can be a daunting task because of the length and complexity of the research conducted. I have conducted a review of reaction time articles and summarized the results into categories. References are listed with each category and can be reviewed in depth at the end under bibliography.

You can use this information to better understand and predict performance under a variety of conditions and situations.

Mean Reaction Times

1. For about 120 years, the accepted figures for mean simple reaction times for college-age individuals have been about 190 ms (0.19 sec) for light stimuli and about 160 ms (0.16) for sound stimuli (Galton, 1899; Fieandt *et al.*, 1956; Welford, 1980; Brebner and Welford, 1980).

Simple vs. Complex Responses & Reaction Times

1. More complex responses also elicit slower reaction times. Henry and Rogers (1960) proposed the "memory drum" theory: that more complex responses require more stored information, and hence take longer. The status of this theory was reviewed by Klapp (2010).

Number of Possible Valid Stimuli.

1. Several investigators have looked at the effect of increasing the number of possible stimuli in recognition and choice experiments. Hick (1952) found that in choice reaction time experiments, response was proportional to log(N), where N is the number of different possible stimuli. In other words, reaction time rises with N, but once N gets large, reaction time no longer increases so much as when N was small. This relationship is called "Hick's Law."
2. Sternberg (1969) maintained that in recognition experiments, as the number of items in the memory set increases, the reaction time rises proportionately (that is, proportional to N, not to log N). Reaction times ranged from 420 msec for 1 valid stimulus (such as one letter in symbol recognition) to 630 msec for 6 valid stimuli, increasing by about 40 msec

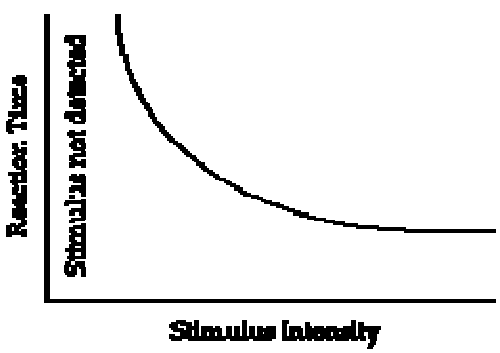
every time another item was added to the memory set. Nickerson (1972) reviewed several recognition studies and agreed with these results.

Type of Stimulus

1. Many researchers have confirmed that reaction to sound is faster than reaction to light, with mean auditory reaction times being 140-160 msec and visual reaction times being 180-200 msec (Galton, 1899; Woodworth and Schlosberg, 1954; Fieandt *et al.*, 1956; Welford, 1980; Brebner and Welford, 1980). Perhaps this is because an auditory stimulus only takes 8-10 msec to reach the brain (Kemp *et al.*, 1973), but a visual stimulus takes 20-40 msec (Marshall *et al.*, 1943).
2. Reaction time to touch is intermediate, at 155 msec (Robinson, 1934). Differences in reaction time between these types of stimuli persist whether the subject is asked to make a simple response or a complex response (Sanders, 1998, p. 114).

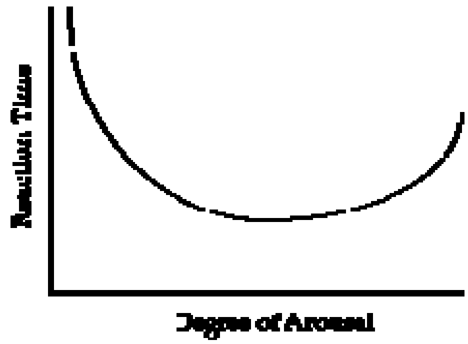
Stimulus Intensity

1. Froeberg (1907) found that visual stimuli that are longer in duration elicit faster reaction times, and Wells (1913) got the same result for auditory stimuli.
2. Piéron (1920) and Luce (1986) reported that the weaker the stimulus (such as a very faint light) is, the longer the reaction time is. However, after the stimulus gets to a certain strength, reaction time becomes constant. In other words, the relationship is:



Arousal

1. One of the most investigated factors affecting reaction time is 'arousal' or state of attention, including muscular tension. Reaction time is fastest with an intermediate level of arousal, and deteriorates when the subject is either too relaxed or too tense (Welford, 1980; Broadbent, 1971; Freeman, 1933). That is, reaction time responds to arousal as follows:



2. while some subjects showed the traditional pattern in the graph above, others showed the opposite trend. In general, reaction time tended to improve as arousal increased. Martinie *et al.* (2010) found that being forced to write an essay defending opinions that the writer

Age

1. Simple reaction time shortens from infancy into the late 20s, then increases slowly until the 50s and 60s, and then lengthens faster as the person gets into his 70s and beyond (Welford, 1977; Jevas and Yan, 2001; Luchies *et al.*, 2002; Rose *et al.*, 2002; Der and Deary, 2006).
2. Luchies *et al.*(2002) also reported that this age effect was more marked for complex reaction time tasks, and Der and Deary (2006) concurred.
3. Reaction time also becomes more variable with age (Hultsch *et al.*, 2002; Gorus *et al.*, 2008).
4. MacDonald *et al.* (2008) found that reaction time variability in older adults was usually associated with slower reaction times and worse recognition of stimuli, and suggested that variability might be a useful measure of general neural integrity.
5. Welford (1980) speculates on the reason for slowing reaction time with age. It is not just simple mechanical factors like the speed of nervous conduction. It may be the tendency of older people to be more careful and monitor their responses more thoroughly (Botwinick, 1966). When troubled by a distraction, older people also tend to devote their exclusive attention to one stimulus, and ignore another stimulus, more completely than younger people.
6. Redfern *et al.*, (2002), & Myerson *et al.* (2007) found that older adults were as adept as younger people at assimilating information, but they did take longer to react.

Gender

1. In almost every age group, males have faster reaction times than females, and female disadvantage is not reduced by practice (Noble *et al.*, 1964; Welford, 1980; Adam *et al.*, 1999; Dane and Erzurumlugoglu, 2003; Der and Deary, 2006). The last study is remarkable because it included over 7400 subjects. Bellis (1933) reported that mean time to press a key in response to a light was 220 msec for males and 260 msec for females; for sound the difference was 190 msec (males) to 200 msec (females).

2. Botwinick and Thompson (1966) found that almost all of the male-female difference was accounted for by the lag between the presentation of the stimulus and the beginning of muscle contraction. Muscle contraction times were the same for males and females.
3. Barral and Debu (2004) found that while men were faster than women at aiming at a target, the women were more accurate.
4. Jevas and Yan (2001) reported that age-related deterioration in reaction time was the same in men and women.

Left vs. Right Hand

1. The hemispheres of the cerebrum are specialized for different tasks. The left hemisphere is regarded as the verbal and logical brain, and the right hemisphere is thought to govern creativity, spatial relations, face recognition, and emotions, among other things. Also, the right hemisphere controls the left hand, and the left hemisphere controls the right hand. This has made researchers think that the left hand should be faster at reaction times involving spatial relationships (such as pointing at a target).
2. Boulinquez and Bartélémy (2000) and Bartélémy and Boulinquez (2001 and 2002) all supported this idea. Dane and Erzurumluoglu (2003) found that in handball players, the left-handed people were faster than right-handed people when the test involved the left hand, but there was no difference between the reaction times of the right and left handers when using the right hand. Finally, although right-handed male handball players had faster reaction times than right-handed women, there was no such sexual difference between left-handed men and women. The authors concluded that left-handed people have an inherent reaction time advantage. In an experiment using a computer mouse, Peters and Ivanoff (1999) found that right-handed people were faster with their right hand (as expected), but left-handed people were equally fast with both hands. The preferred hand was generally faster. However, the reaction time advantage of the preferred over the non-preferred hands was so small that they recommended alternating hands when using a mouse. Derakhshan (2006 and 2009) cautions that preferred hand is not always a good guide to the dominant hemisphere. In most people, a dominant (and faster) right hand implies a dominant left hemisphere. However, he found that a minority (20%-25%) of right-handed people actually had a dominant *right* hemisphere, and that reaction time on the right side of the body was slower in these people because commands had to originate in the right hemisphere and then cross over to the left hemisphere, and then get to the right hand. In other words, the side of the body with the longer reaction time (not always the side with the nonpreferred hand) is the side with the dominant hemisphere. Bryden (2002), using right-handed people only, found that task difficulty did not affect the reaction time difference between the left and right hands. Miller and Van Nes (2007) found that responses involving both hands were faster when the stimulus was presented to both hemispheres of the brain simultaneously. Because the right (emotional) hemisphere is supplied with input by the left eye, it might be suspected that the left visual field would be the fastest at identifying emotions. Alves *et al.* (2009) confirmed that faces showing happiness or fear were identified most rapidly when presented to the left visual field (e.g., and examined by the right hemisphere), and that neutral expressions were detected most rapidly by the right visual field. Godard and Fiori (2010) found that men

are just as accurate at face recognition as women, but that women were faster. They also found that men were more strongly "lateralized" than women, with dominance of the right cerebral hemisphere. Muscians appear to have hemispheres that are more equally capable of paying attention to stimuli than non-muscians, and to have faster reaction times as well (Patston *et al.*, 2007).

Direct vs. Peripheral Vision

1. Brebner and Welford (1980) cite literature that shows that visual stimuli perceived by different portions of the eye produce different reaction times. The fastest reaction time comes when a stimulus is seen by the cones (when the person is looking right at the stimulus).
2. If the stimulus is picked up by rods (around the edge of the eye), the reaction is slower.
3. Ando *et al.*, 2002 found that practice on a visual stimulus in central vision shortened the reaction time to a stimulus in peripheral vision, and *vice versa.*

Practice and Errors

1. Sanders (1998, p. 21) cited studies showing that when subjects are new to a reaction time task, their reaction times are less consistent than when they've had an adequate amount of practice.
2. Also, if a subject makes an error, subsequent reaction times are slower, as if the subject is being more cautious. Koehn *et al.* (2008) also found that "accusing" subjects of making an error slowed their processing of the next stimulus more than indicating that they had made a correct choice.
3. Ando *et al.* (2002) found that reaction time to a visual stimulus decreased with three weeks of practice, and the same research team (2004) reported that the effects of practice last for at least three weeks.
4. Fontani *et al.* (2006) showed that in karate, more experienced practitioners had shorter reaction times, but in volleyball, the inexperienced players had shorter reaction times (and made more errors too). Visser *et al.* (2007) found that training on a complex task both shortened reaction time and improved accuracy.

Fatigue.

1. Welford (1968, 1980) found that reaction time gets slower when the subject is fatigued.
2. Singleton (1953) observed that this deterioration due to fatigue is more marked when the reaction time task is complicated than when it is simple.
3. Mental fatigue, especially sleepiness, has the greatest effect.
4. Kroll (1973) found no effect of purely muscular fatigue on reaction time. Philip *et al.* (2004) found that 24 hours of sleep deprivation lengthened the reaction times of 20-25 year old subjects, but had no effect on the reaction times of 52-63 year old subjects.

5. Van den Berg and Neely (2006) found that sleep deprivation caused subjects to have slower reaction times and to miss stimuli over a test period that lasted two hours. Cote *et al.* (2009) had the same conclusions about two days of restricted sleep, and also found that the more restricted sleep was, the worse the deterioration in reaction time, and the subjects seemed to be compensating for this by more mental effort (measured by high-frequency EEG waves).
6. Takahashi *et al.* (2004) studied workers who were allowed to take a short nap on the job, and found that although the workers thought the nap had improved their alertness, there was no effect on choice reaction time.

Distraction

1. Welford (1980) and Broadbent (1971) reviewed studies showing that distractions increase reaction time.
2. Trimmel and Poelzl (2006) found that background noise lengthened reaction time by inhibiting parts of the cerebral cortex.
3. Richard *et al.* (2002) and Lee *et al.* (2001) found that college students given a simulated driving task had longer reaction times when given a simultaneous auditory task. They drew conclusions about the safety effects of driving while using a cellular phone or voice-based e-mail. Horrey and Wickens (2006) and Hendrick and Switzer (2007) had similar conclusions about cell phone use while driving, and said that hands-free phones did not improve reaction time performance. Reaction time suffered more than tasks like keeping in the right lane. Redfern *et al.* (2002) found that subjects strapped to a platform that periodically changed orientation had slowed reaction time before and during platform movement. The reaction time to auditory stimuli was more affected than response to visual stimuli. Hsieh *et al.* (2007) found that simulated vibration of a computer monitor increased reaction times to stimuli presented on the monitor, worsened error rates, and caused more visual fatigue. The effect of distraction may depend on emotional state and prior experiences. Reed and Antonova (2007) frustrated some subjects by giving them unsolvable problems, and then tested the reaction times of all the subjects with distraction. Subjects who had been given the difficult problems were more slowed and distracted than subjects who had not been frustrated before the reaction time measurement. Similar results were cited by Gerdes *et al.* (2008), who found that subjects who were phobic about spiders had their reaction time slowed more by distracting pictures of spiders than by distracting pictures of objects like flowers and mushrooms. This was caused by the phobic subjects' failure to look away from the spider pictures as fast as they looked away from the other pictures. Martinie *et al.* (2010) found that being forced to write an essay defending opinions that the writer did not really share actually improved reaction time, possibly due to increased arousal.

Warnings of Impending Stimuli

1. Brebner and Welford (1980) report that reaction times are faster when the subject has been warned that a stimulus will arrive soon.

2. Bertelson (1967) found that as long as the warning was longer than about 0.2 sec., the shorter the warning was, the faster reaction time was. This effect probably occurs because attention and muscular tension cannot be maintained at a high level for more than a few seconds.
3. Gottsdanker, (1975). Jakobs *et al.* (2009) found that stimuli that were predictable elicited faster reaction times, probably because of decreased computational load on the brain. Also, warning of the stimulus can increase the number of erroneous responses given before the stimulus (O'Neill and Brown, 2007).

Alcohol

1. Hernandez *et al.* (2007) found that the slowing of reaction time by alcohol was due to a slowing of muscle activation, not muscle action.
2. Fillmore and Blackburn (2002) found that subjects who had drunk an impairing dose of alcohol reacted faster when they were warned that this was enough alcohol to slow their reaction time. Unwarned subjects who drank suffered more decreased reaction times. However, the warned subjects were also less inhibited and careful in their responses. Even subjects who drank some non-alcoholic beverage and then were warned (falsely) about impairment by alcohol reacted faster than unwarned subjects who drank the same beverage.

Order of Presentation

1. Welford (1980), Laming (1968) and Sanders (1998) observed that when there are several types of stimuli, reaction time will be faster where there is a 'run' of several identical stimuli than when the different types of stimuli appear in mixed order. This is called the "sequential effect."
2. Hsieh (2002) found that the shifting of attention between two different types of tasks caused an increase in reaction time to both tasks.

Breathing Cycle.

1. Buchsbaum and Calloway (1965) found that reaction time was faster when the stimulus occurred during expiration than during inspiration.

Personality Type

1. Brebner (1980) found that extroverted personality types had faster reaction times, and Welford (1980) and Nettelbeck (1973) said that anxious personality types had faster reaction times.

Exercise

1. Exercise can affect reaction time. Welford (1980) found that physically fit subjects had faster reaction times, and both Levitt and Gutin (1971) and Sjoberg (1975) showed that

subjects had the fastest reaction times when they were exercising sufficiently to produce a heartrate of 115 beats per minute.

2. Kashihara and Nakahara (2005) found that vigorous exercise did improve choice reaction time, but only for the first 8 minutes after exercise.

Punishment, Stress, & Threats

1. Punishing a subject when he reacts slowly does shorten reaction time (Johanson, 1922; Weiss, 1965).
2. Simply making the subject feel anxious about his performance has the same effect, at least on simple reaction time tasks (Panayiotou, 2004).
3. Mogg *et al.* (2008) found that it might be hard to disentangle the effects of threat-induced anxiety from the simple distraction that the threat was causing. In other words, even a non-threatening stimulus can cause distraction and slow reaction time, but not by causing anxiety.
4. Verlasting (2006) found that deployment to Iraq caused soldiers to have shorter reaction times, but also increased tension and reduced proficiency at tasks requiring memory and attention. In any timed task, there are speed-accuracy tradeoffs. For example, if speed is rewarded more than accuracy, reaction times will be shorter than when heavy penalties are attached to making mistakes.
5. Simen *et al.* (2009) produced a model of this situation, and found that human subjects adjusted their speed and accuracy to optimize their rewards, just as the model had predicted.

Stimulant Drugs

1. Caffeine has often been studied in connection with reaction time. Lorist and Snel (1997) found that moderate doses of caffeine decreased the time it took subjects to find a target stimulus and to prepare a response for a complex reaction time task.
2. Durlach *et al.* (2002) found that the amount of caffeine in one cup of coffee did reduce reaction time and increase ability to resist distraction, and did so within minutes after consumption.
3. McLellan *et al.* (2005) found that soldiers in simulated urban combat maintained their marksmanship skills and their reaction times through a prolonged period without sleep better when given caffeine.
4. Liguori *et al.* (2001) found that caffeine can reduce the slowing effect of alcohol on reaction time, but can't prevent other effects such as body sway.
5. O'Neill and Brown (2007) found that amphetamine and a drug called KW-6002 speeded reaction times and also increased the frequency of erroneous responses before the stimulus in the hyper-alert participants.

Intelligence

1. Among people of normal intelligence, there is a slight tendency for more intelligent people to have faster reaction times, but there is much variation between people of similar intelligence (Nettelbeck, 1980).
2. The speed advantage of more intelligent people is greatest on tests requiring complex responses (Schweitzer, 2001).

Illness

1. Minor upper respiratory tract infections slow reaction time, make mood more negative, and cause disturbance of sleep (Smith *et al.*, 2004).

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