NEURO INSTITUTE

Continuing Education for Rehabilitation Professionals

Applied Behavioral Economics for Clinicians Serving Individuals with Brain Injury

Karl Gunnarsson, M.S., BCBA

Objectives

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- Participants will have a basic understanding of applied behavioral economics.
- Participants will be able to define choice impulsivity.
- Participants will have a basic understanding of delay and probability discounting.
- Participants will understand clinical implications of discounting research.


National Capital (117,000 in 2008)
over 5,000
other main city
other city
Capital of region
Denmark Strait
Ísafjarðardjúp
Horn
Grímsey
Kísilstangi
Raufarhöfn
Öxarfjörður
Kópasker
Þistilfjörður
Þórshöfn
Bakkaflói
Bakkafjörður
Vopnafjörður
Vopnafjörður
Eyjafjörður
Skjálfandi
Húsavík
Ólafsfjörður
Grenivík
Siglufjörður
Skagafjörður
Hofsós
Dalvík
Sauðárkrókur
Húnaflói
Skagaströnd
Blönduós
Osar
Varmahlíð
Hvammstangi
Hólmavík
Bíldudalur
Patreksfjörður
Bjakalundur
Króksfjarðarnes
Breiðafjörður
Bordheyri
Búðardalur
Stykkishólmur
Hellissandur
Grundarfjörður
Ísafjörður
Bolungarvík
Flateyri
Drangajökull
VESTFIRÐIR
Arnarfjörður
Þingeyri
VESTURLAND
Borgarnes
Faxaflói
Akranes
REYKJANES
REYKJAVÍK
Hafnarfjörður
Kópavogur
Keflavík
Garðabær
REYKJANES
Grindavík
Þorlákshöfn
Þingvellir
Geysir
Þingvallavatn
Laugarás
Selfoss
Eyrarbakki
Hella
Hvolsvöllur
Skógar
Vík
Vestmannaeyjar
Heimaey
Surtsey
NORÐURLAND VESTRA
NORÐURLAND EYSTRA
Akureyri
Reykjahlíð
Myvatn
Grímsstaðir
Egilsstaðir
Seyðisfjörður
Neskaupstaður
Eskifjörður
Búðir
Breiðdalsvík
Djúpivogur
Höfn
Hornafjörður
AUSTURLAND
Hofsjökull
Langjökull
Vatnajökull
Öræfajökull
Þórisvatn
SUÐURLAND
Hekla
Kirkjubæjarklaustur
Fagurhólsmýri
Myrdalsjökull
Eyjafjallajökull
Askja
Bárðarbunga
Grímsvötn
Kverkfjöll
Snæfell
Herðubreið
Einkasjökull
Hekla (Vavaland)
2000 m
1500 m
1000 m
500 m
200 m
100 m
0 m
ICELAND
0 km 20 40 60 km
© 2009 Ezilon.com All Right Reserved
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Ísafjarðardjúp
Bolungarvík
Ísafjörður
925
Drangajökull
Flateyri
VESTFIRÐIR
Arnarfjörður
Þingeyri
Bíldudalur
Hólmavík
Patreksfjörður
Bjakalundur
Króksfjarðarnes

Learning Objectives

Be able to define choice impulsivity.

Acquire a basic understanding of delay and probability discounting.

Understand clinical implications of discounting research.

Impulsivity

Choice Impulsivity

Choice impulsivity refers to likelihood that a person, who is impulsive, may forgo a larger more beneficial reward because its delivery is distant in time, and choose a smaller reward because it can be acquired immediately or with limited delay

"You can eat the one marshmallow right now, or, if you wait fifteen minutes, I'll give you two marshmallows and swear you in as President of the United States."

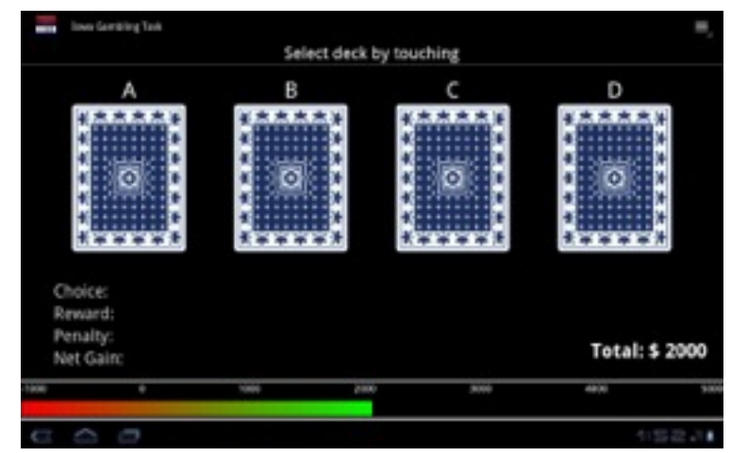
From the New Yorker

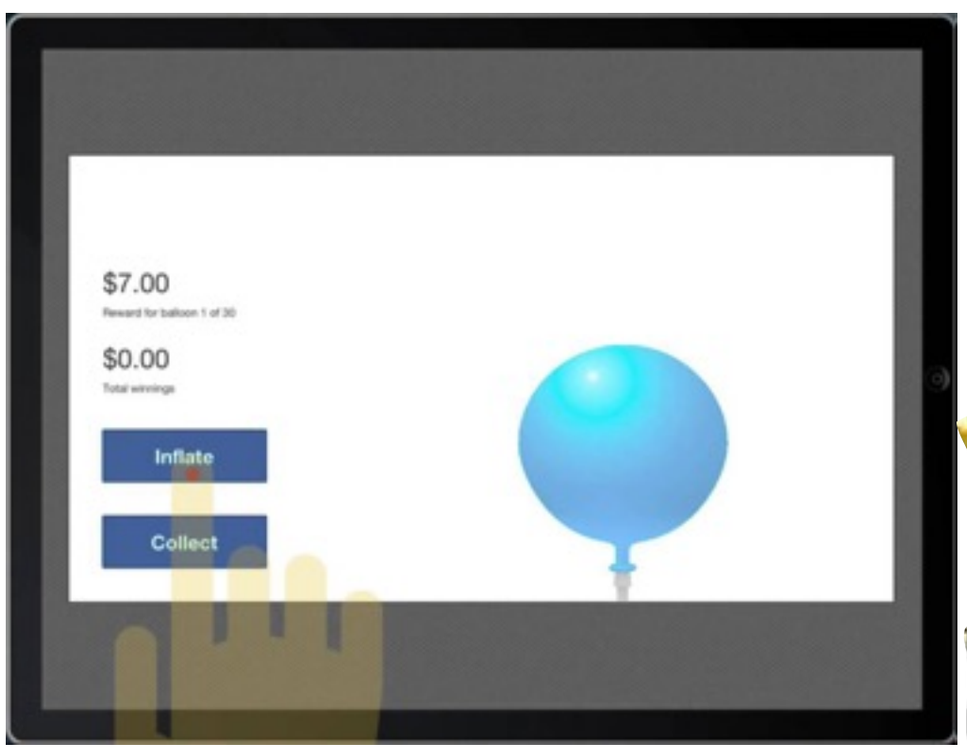
Choice Impulsivity


ONE LOVE
BLACK JACK PAYS 3TO 2
Dealer must draw to 16, and stand on all 17's
PAYS 2TO1
PAYS 2TO1
INSURANCE
JACK DANIEL'S
No.7
Tennessee
WHISKEY


EDUCATION

Traditional measurements of impulsivity within the brain injury literature

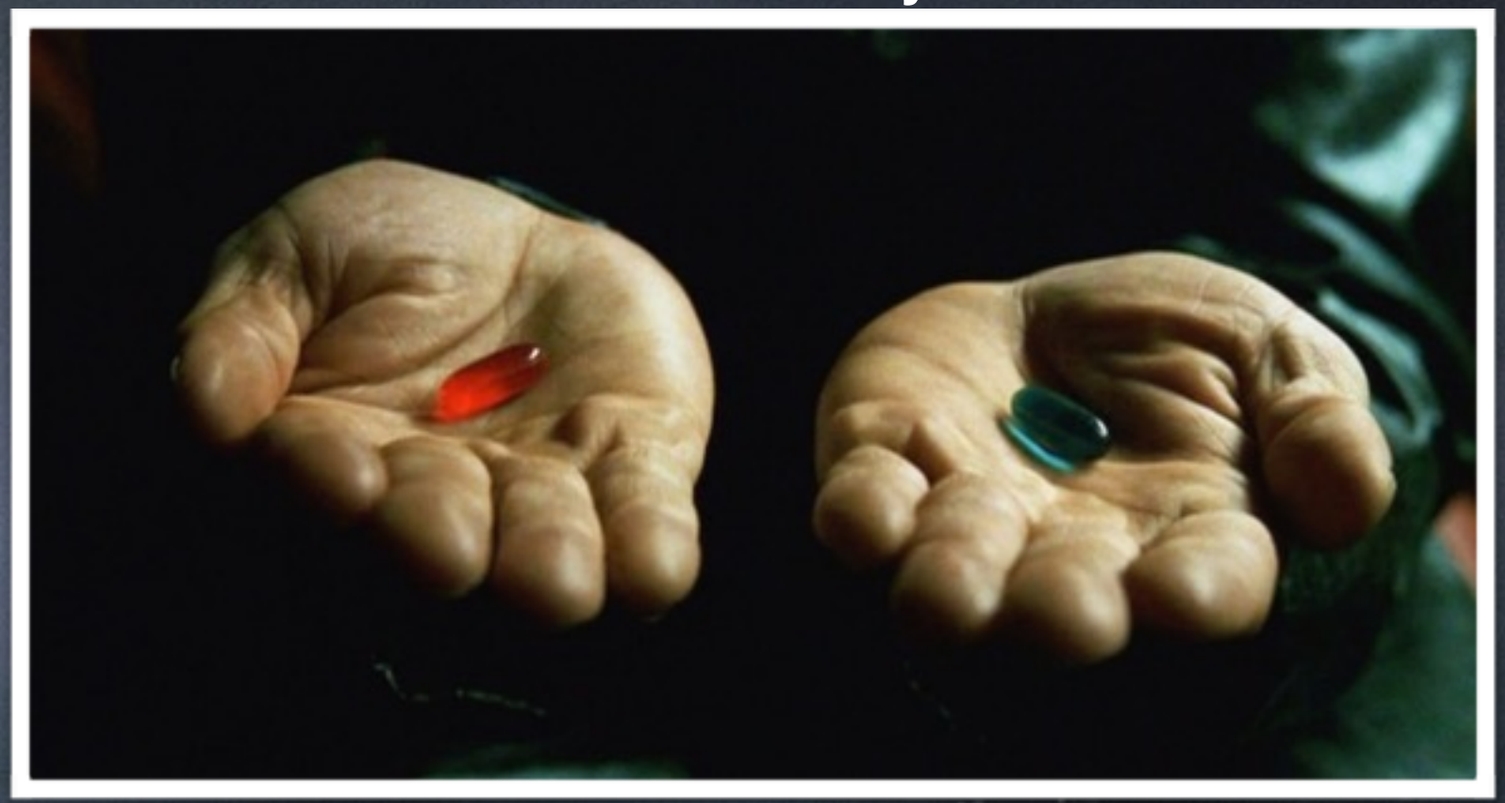




Imagine that someone would offer you a choice between $950 now, or $1000 in one week from now. What would you choose?

How about $500 now or $1000 in three years from now?

Said differently!



Delay discounting is the functional relationship between time and subjective value of a reward

—that is—

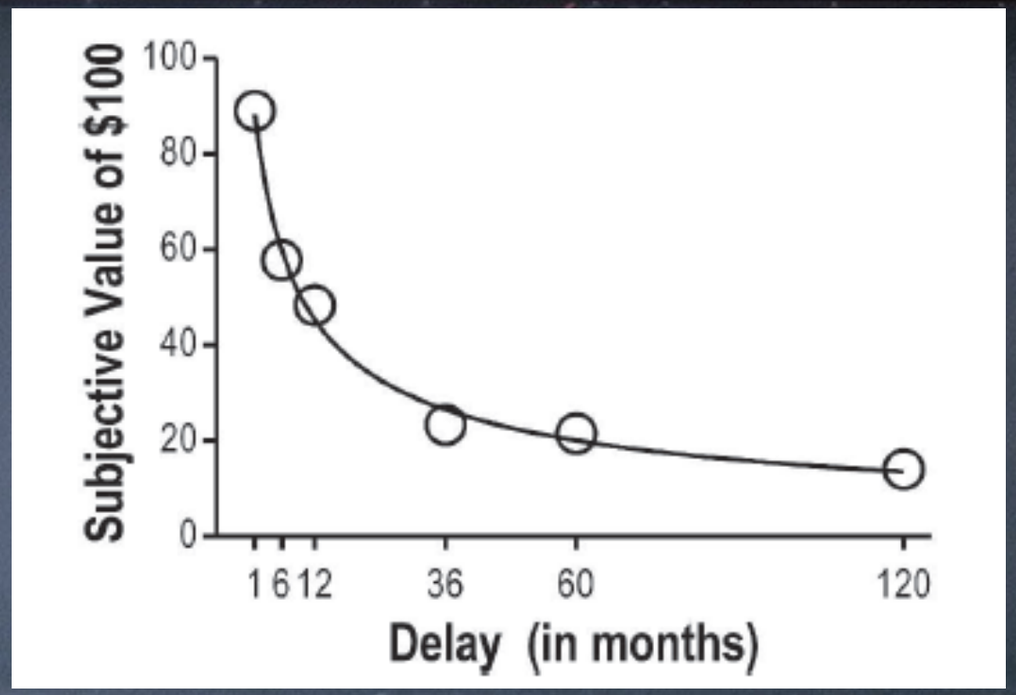
As time increases the subjective value of a reward will decrease

Now imagine that someone would offer you a choice between $500 for sure, or a 95% of receiving $1000. What would you choose?

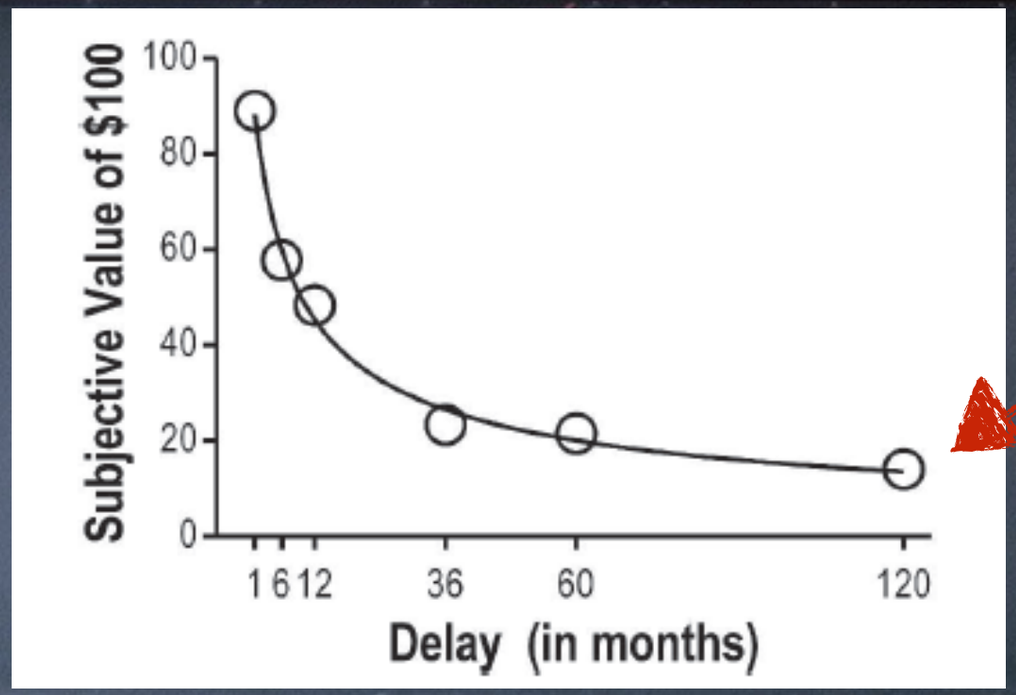
How about $500 for sure or 50% of receiving $1000?

Said differently!

Probability discounting is the functional relationship between probability of receiving a reward and subjective value of that reward
—that is—
As odds against increase the subjective value of a reward will decrease

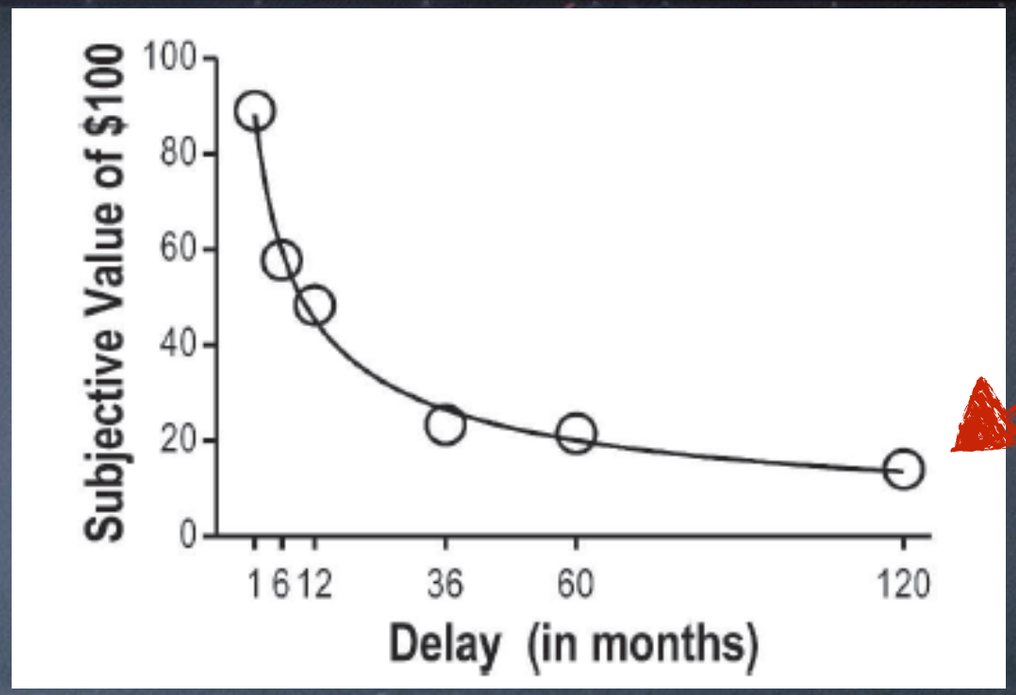


"At their heart, delay-discounting procedures are about finding the point at which two rewards, one relatively immediate and one delayed, have approximately the same value." (Odom, 2011, p. 428)



Indifference point

Now	Later
$950	~~$1000~~
$800	~~$1000~~
~~$750~~	$1000
~~$600~~	$1000
~~$500~~	$1000
~~$400~~	$1000



Indifference point

Now		Later
$950		~~$1000~~
	$800	~~$1000~~
		$1000
~~$600~~	=775	$1000
~~$500~~	$750	$1000
~~$400~~		$1000

Different methods

Rachlin et al., 1991

Now $95 ..... $1

Later $100

Johnson & Bickel, 2002

Du et al., 2002

Now $50

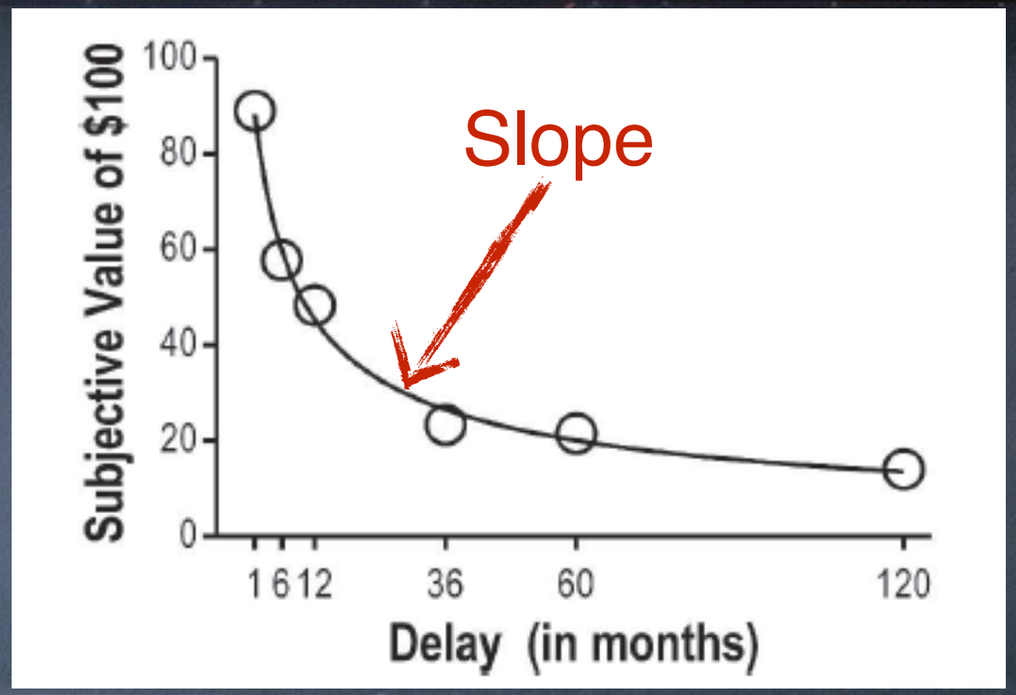
Later $100

Reynolds & Schiffbauer, 2004

Now % + T

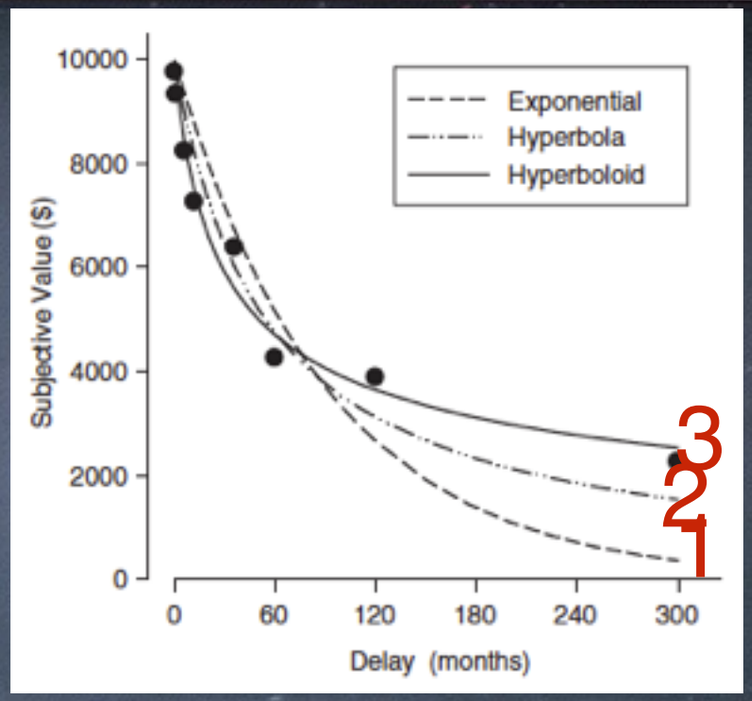
Later % + T

Real money and waiting



Three methods

Exponential	Hyperbolic	Hyperboloid
$V = Ae^{-kD}$	$V = A/(1 + kD)$	$V = A/(1 + kD)^s$



1
Exponential
$V = Ae^{-kD}$

2
Hyperbolic
$V = A/(1 + kD)$

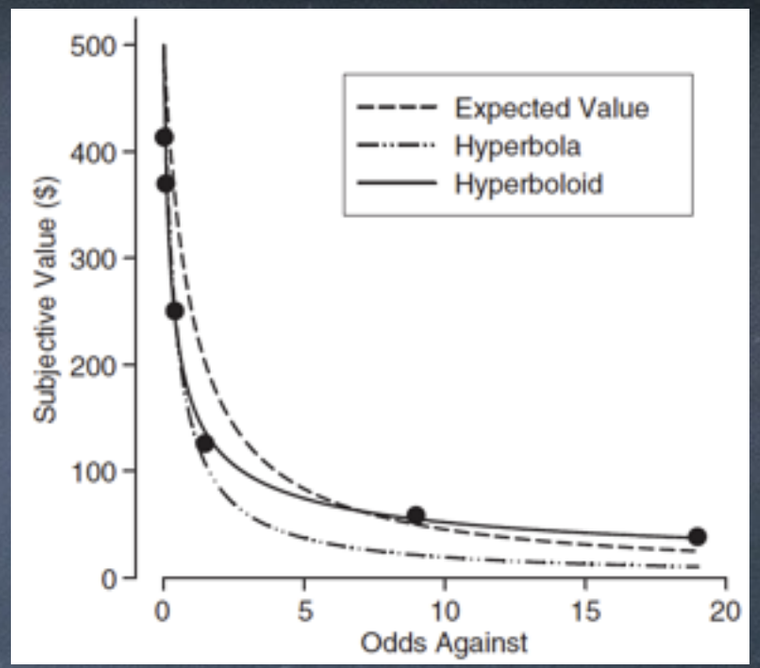
3
Hyperboloid
$V = A/(1 + kD)^s$

↑ k = higher impulsivity

$k = ((A/V) - 1)/D.$

9AM: Egg whites and Avocado
1PM: Kale Salad
6PM: Chicken and Veggies
11PM: 23 Oreos + Tub of ice cream


A
Exponential Discounting
LL
SS
Discounted Value
Decision Maker's Position in Time
B
Hyperbolic Discounting: Low k
LL
SS
Discounted Value
Decision Maker's Position in Time
C
Hyperbolic Discounting: High k
LL
SS
Discounted Value
Decision Maker's Position in Time

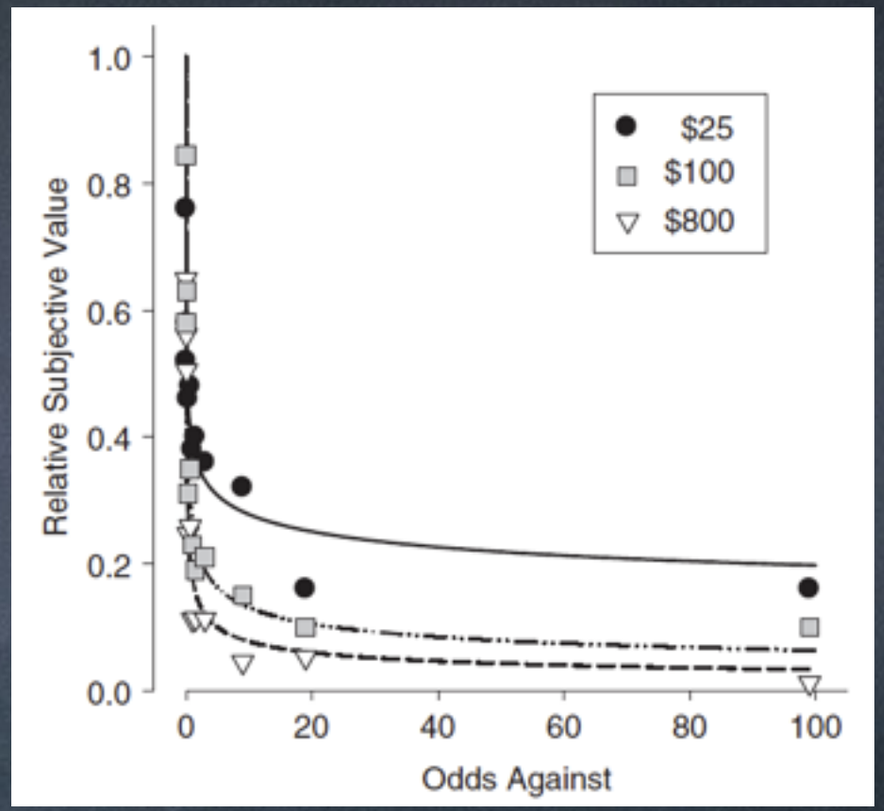


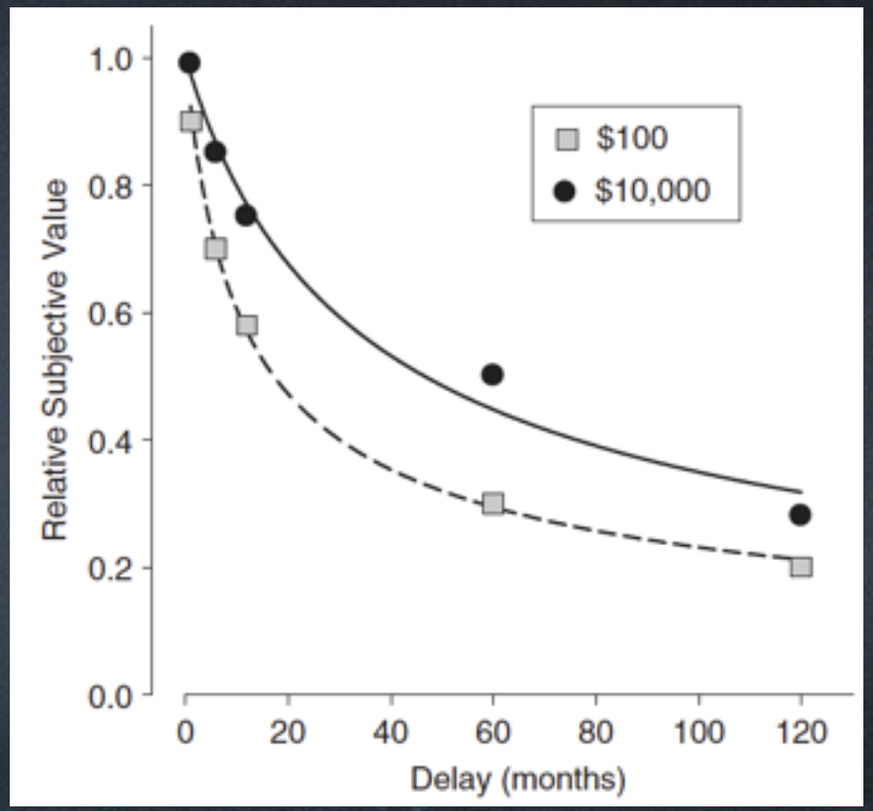
Exponential	Hyperbolic	Hyperboloid
$V = Ae^{-hO}$	$V = A/(1 + hO)$	$V = A/(1 + hO)^s$

↓ *h* = higher impulsivity

Do we discount everything the same?

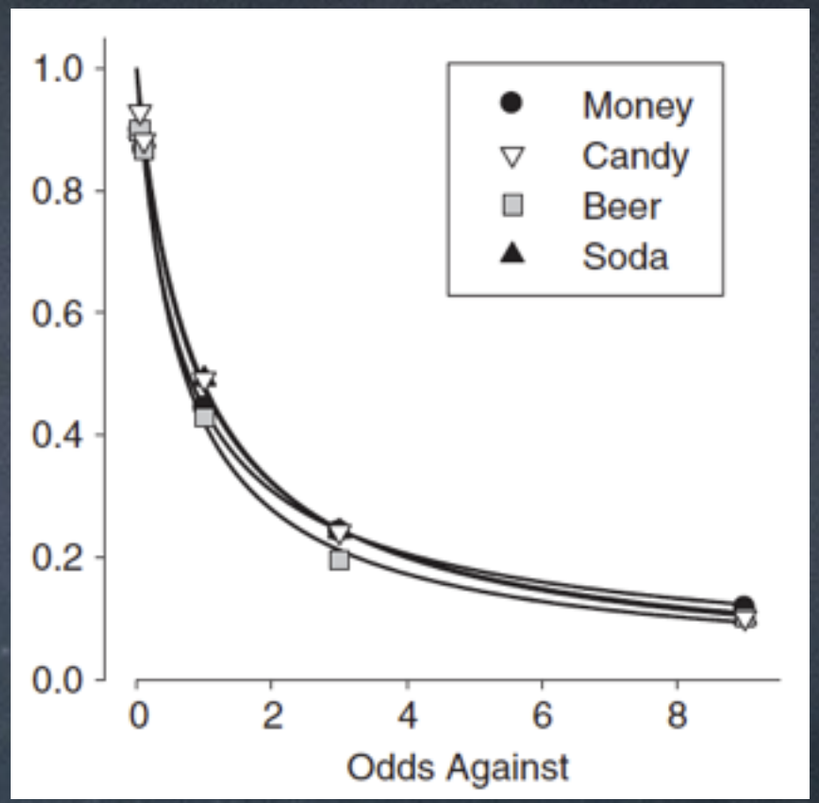
Amount

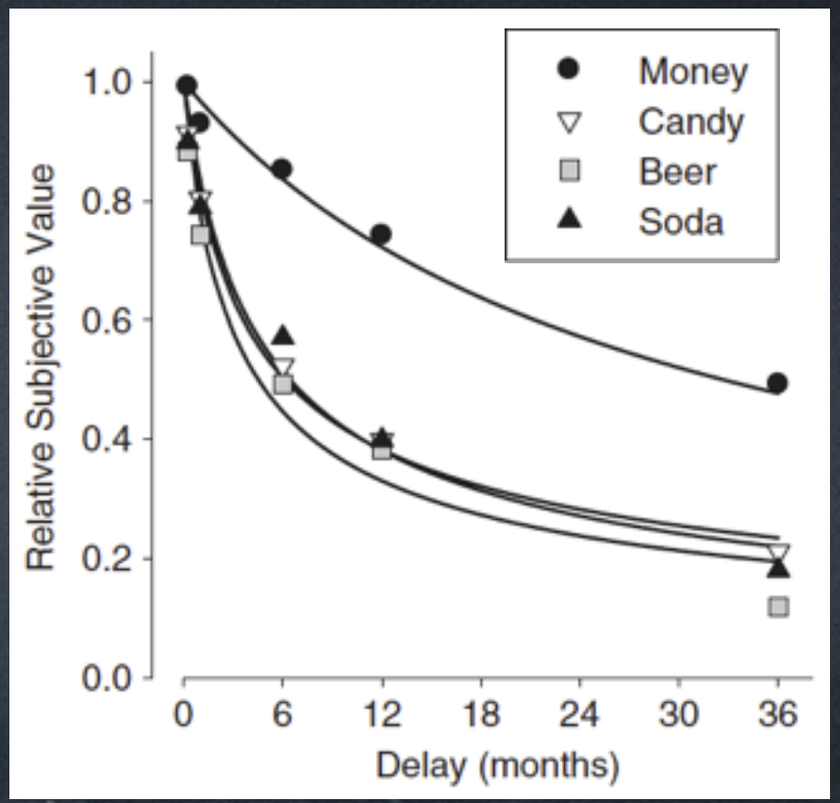




Do we discount everything the same?

Type of reward



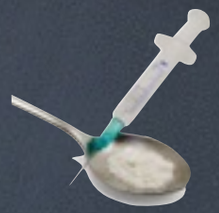


The rate of discounting appears stable over time for many different clinical populations

Kids who discount steeply become steep discounters later

College students (no clinical diagnosis) discount at same rate, up to a year later

How about TBI folks?



How about TBI folks?

Reduced Sensitivity to Sooner Reward During Intertemporal Decision-Making Following Insula Damage in Humans

Manuela Sellitto[1,2], Elisa Ciaramelli[1,2], Flavia Mattioli[3] and Giuseppe di Pellegrino[1,2]*

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During intertemporal choice, humans tend to prefer small-sooner rewards over larger-delayed rewards, reflecting temporal discounting (TD) of delayed outcomes. Functional neuroimaging (fMRI) evidence has implicated the insular cortex in time-sensitive decisions, yet it is not clear whether activity in this brain region is crucial for, or merely associated with, TD behavior. Here, patients with damage to the insula (insular patients), control patients with lesions outside the insula, and healthy individuals chose between smaller-sooner and larger-later monetary rewards. Insular patients were less sensitive to sooner rewards than were the control groups, exhibiting reduced TD. A Voxel-based Lesion-Symptom Mapping (VLSM) analysis confirmed a statistically significant association between insular damage and reduced TD. These results indicate that the insular cortex is crucial for intertemporal choice. We suggest that he insula may be necessary to anticipate the bodily/emotional effects of receiving rewards at different delays, influencing the computation of their incentive value. Devoid of such input, insular patients' choices would be governed by a heuristic of quantity, allowing patients to wait for larger options.

Keywords: emotion, insular cortex, limbic system, reward, temporal discounting, visceral factors

Behavioral/Systems/Cognitive

Myopic Discounting of Future Rewards after Medial Orbitofrontal Damage in Humans

Manuela Sellitto,[1,2] Elisa Ciaramelli,[2] and Giuseppe di Pellegrino[1,2]

[1]Dipartimento di Psicologia, Università di Bologna, 40127 Bologna, Italy, and [2]Centro studi e ricerche in Neuroscienze Cognitive, Polo Scientifico-Didattico di Cesena, 47521 Cesena, Italy

Choices are often intertemporal, requiring tradeoff of short-term and long-term outcomes. In such contexts, humans may prefer small rewards delivered immediately to larger rewards delivered after a delay, reflecting temporal discounting (TD) of delayed outcomes. The medial orbitofrontal cortex (mOFC) is consistently activated during intertemporal choice, yet its role remains unclear. Here, patients with lesions in the mOFC (mOFC patients), control patients with lesions outside the frontal lobe, and healthy individuals chose hypothetically between small-immediate and larger-delayed rewards. The type of reward varied across three TD tasks, including both primary (food) and secondary (money and discount vouchers) rewards. We found that damage to mOFC increased significantly the preference for small-immediate over larger-delayed rewards, resulting in steeper TD of future rewards in mOFC patients compared with the control groups. This held for both primary and secondary rewards. All participants, including mOFC patients, were more willing to wait for delayed money and discount vouchers than for delayed food, suggesting that mOFC patients' (impatient) choices were not due merely to poor motor impulse control or consideration of the goods at stake. These findings provide the first evidence in humans that mOFC is necessary for valuation and preference of delayed rewards for intertemporal choice.

Using a temporal discounting paradigm to measure decision-making and impulsivity following traumatic brain injury: A pilot study

LOUISE McHUGH & RODGER L. WOOD

Brain Injury Research Group, Department of Psychology, University of Wales Swansea, UK

(Received 26 February 2008; accepted 7 June 2008)

Abstract

Primary objective: This study reports on a pilot study using a temporal discounting paradigm and a standardized impulsivity questionnaire to examine decision-making in a group of brain injured patients and age matched controls.

Methods and procedures: Participants were asked to choose between a larger reward available at a specified time in the future and smaller reward available immediately.

Outcome and results: Each of the two groups demonstrated temporal discounting; that is, the subjective value of the reward decreased with increasing delay. However, the TBI group discounted more than the controls, suggesting that their decision-making was more impulsive.

Conclusion: The results suggest that a temporal discounting paradigm might be a useful method of assessing decision-making after head trauma, especially in cases where capacity to make decisions about financial awards is an issue or in respect of money management generally.

Keywords: *Temporal discounting, traumatic brain injury, decision-making, impulsivity*

IMPULSIVITY, SELF-CONTROL, AND DELAY DISCOUNTING IN PERSONS WITH ACQUIRED BRAIN INJURY

Mark R. Dixon[1]*, Eric A. Jacobs[1], Scott Sanders[1], John M. Guercio[2], James Soldner[1], Susan Parker-Singler[1], Ashton Robinson[1], Stacey Small[1] and Jeffrey E. Dillen[1]

[1]Southern Illinois University, Carbondale, IL, USA
[2]Center for Comprehensive Services, Mentor ABI Network, Carbondale, IL, USA

The present paper describes two studies in which participants with and without acquired brain injuries were compared on a temporal discounting task involving various hypothetical amounts of money available at varying delay values. During Experiment 1, both groups of participants were presented with choices between amounts of money ranging from 1 to 1000 US dollars at delays from 1 week to 10 years. The results obtained from this procedure were consistent with previous models of temporal delay discounting for control group participants, yet not for the majority of the participants with acquired brain injuries. During Experiment 2, adjustments in hypothetical amounts and delays were made whereby the amounts of money ranged from 1 to 20 US dollars at delays from 1 day to 1 year. These manipulations yielded data generally consistent with temporal delay discounting models previously reported in the published literature. The utility of using delay discounting procedures as a means of assessing impulsivity in persons with acquired brain injuries is presented. Copyright © 2005 John Wiley & Sons, Ltd.

Decision Making after Traumatic Brain Injury: A Temporal Discounting Paradigm

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[1]Psychology Department, Swansea University, Swansea, Wales
[2]School of Psychology, University College Dublin, Dublin, Ireland

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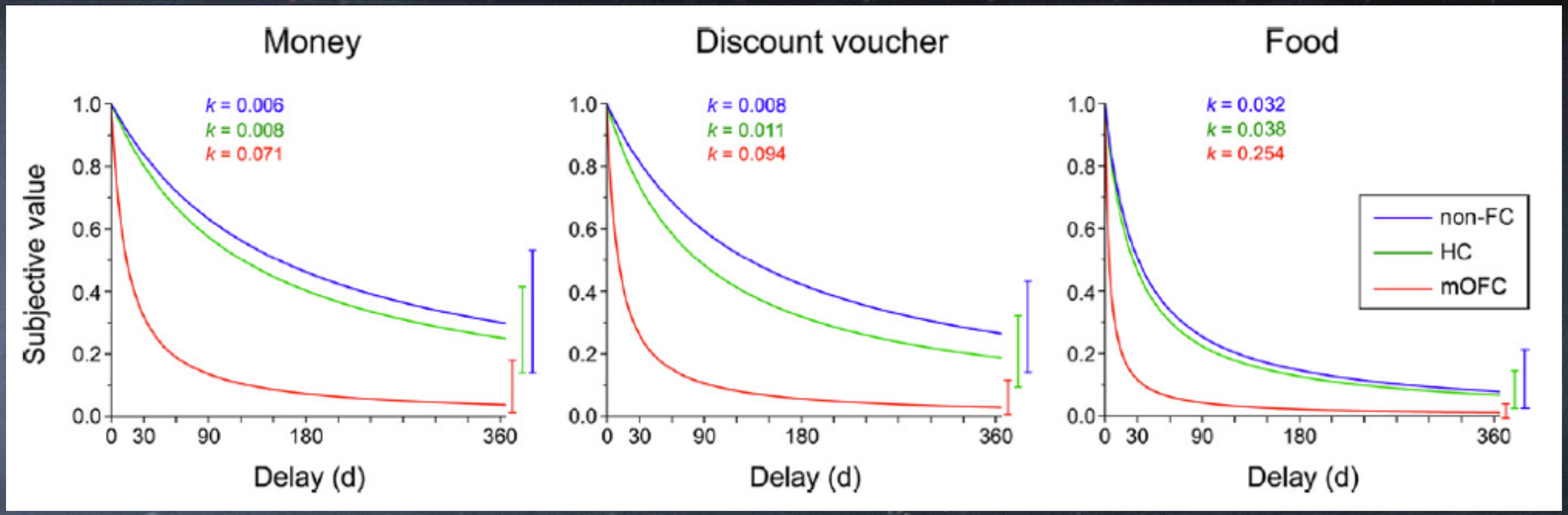
Abstract

A temporal discounting paradigm was used to examine decision making for hypothetical monetary reward following traumatic brain injury (TBI). A case-control design compared individuals following moderate or severe TBI with a healthy control group matched for age and gender. The impact of intelligence, impulsivity, and mood on temporal discounting performance was examined. A within-subjects design for the TBI group determined the influence of a range of neuropsychological tests on temporal discounting performance. Both patients and controls demonstrated temporal discounting. However, the TBI group discounted more than controls, suggesting that their decision making was more impulsive, consistent with ratings on the impulsiveness questionnaire. Discounting performance was independent of neuropsychological measures of intelligence, memory, and executive function. There was no relationship between temporal discounting and ratings of everyday executive function made by patients' relatives. Low mood did not account for discounting performance. The results of this study suggest that temporal discounting may be a useful neuropsychological paradigm to assess decision making linked to monetary reward following TBI. Performance was relatively independent of intelligence, memory and standard tests of executive ability and may therefore assist when assessing a patient's mental capacity to manage their financial affairs. (JINS, 2013, 19, 181–188)

Keywords: Brain injuries, TBI, Impulsive behavior, Neuropsychological tests, Executive function, Decision-making


Money
Discount voucher
Food
k = 0.006
k = 0.008
k = 0.071
k = 0.008
k = 0.011
k = 0.094
k = 0.032
k = 0.038
k = 0.254
Subjective value
1.0
0.8
0.6
0.4
0.2
0.0
0
30
90
180
360
Delay (d)
non-FC
HC
mOFC

How can we alter discounting?

Trans magnetic stimulation
Working memory
Reframing
Episodic future thinking
Derived relational responding
Contingency management programs

How can we alter discounting?

Working memory

Contingency management programs

Derived relational training

Reframing

Episodic future thinking

How can we alter discounting?

Working memory

How can we alter discounting?

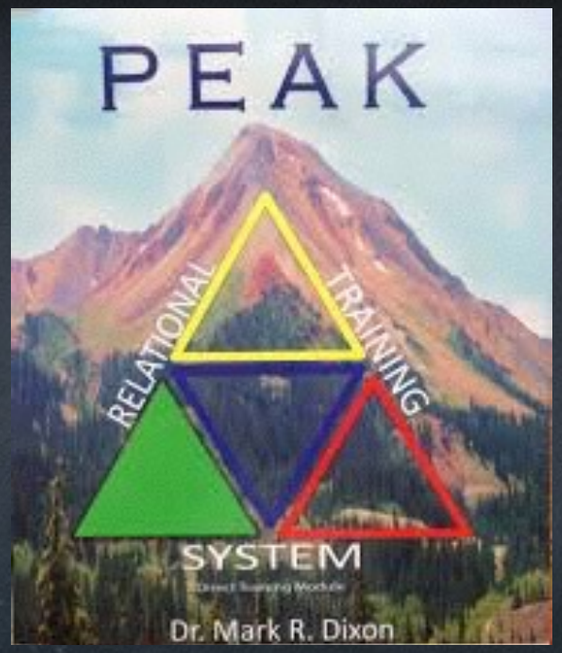
Reframing

How can we alter discounting?

Episodic future thinking

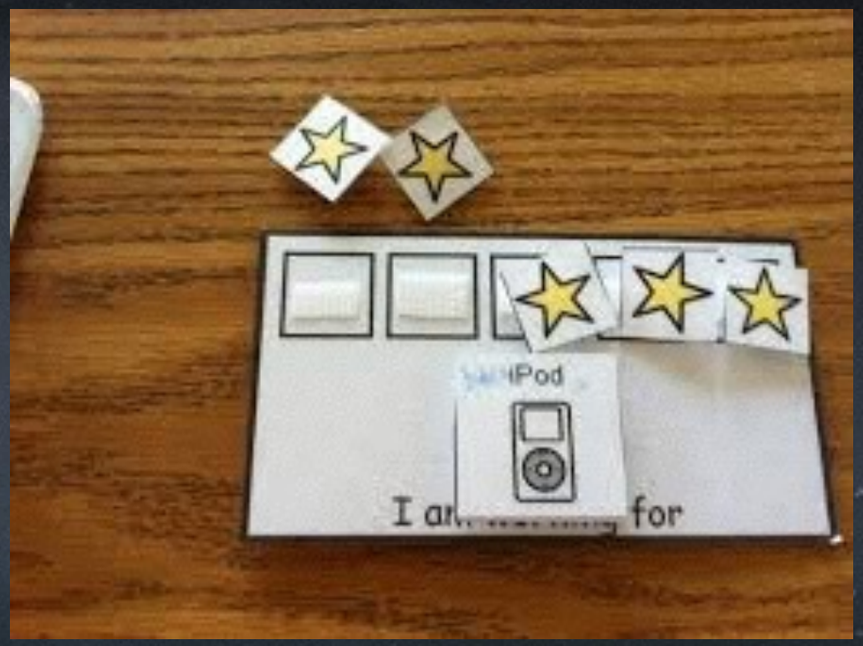
How can we alter discounting?

Derived relational responding



How can we alter discounting?

Contingency management programs



JOURNAL OF APPLIED BEHAVIOR ANALYSIS 2004, **37,** 101–105 NUMBER 1 (SPRING 2004)

PREFERENCE FOR PROGRESSIVE DELAYS AND CONCURRENT PHYSICAL THERAPY EXERCISE IN AN ADULT WITH ACQUIRED BRAIN INJURY

MARK R. DIXON AND TERRY S. FALCOMATA

SOUTHERN ILLINOIS UNIVERSITY

The purpose of this study was to increase self-control and engagement in a physical therapy task (head holding) for a man with acquired traumatic brain injury. Once impulsivity was observed (i.e., repeated impulsive choices), an experimental condition was introduced that consisted of choices between a small immediate reinforcer, a large fixed-delay reinforcer, and a large progressive-delay reinforcer. The participant showed a preference for the progressive-delay option, even when the duration of the delay exceeded that of the fixed delay. The results have implications for establishing optimal choice making and teaching life-enhancing skills.

DESCRIPTORS: brain injury, impulsivity, physical therapy, self-control

JOURNAL OF APPLIED BEHAVIOR ANALYSIS 2003, **36,** 371–374 NUMBER 3 (FALL 2003)

SELF-CONTROL AND THE PREFERENCE FOR DELAYED REINFORCEMENT: AN EXAMPLE IN BRAIN INJURY

MARK R. DIXON AND MOLLIE J. HORNER

SOUTHERN ILLINOIS UNIVERSITY

AND

JOHN GUERCIO

CENTER FOR COMPREHENSIVE SERVICES

We investigated the effects of a concurrent physical therapy activity (keeping the hand open) during delays to reinforcement in an adult man with acquired brain injuries. Once a relatively stable level of hand-open behavior was obtained, the participant was asked to choose between a small immediate reinforcer and a larger delayed reinforcer contingent on keeping the hand open at greater-than-baseline duration. Afterwards, the participant was asked to select between a larger delayed reinforcer with no hand-open requirement and the identical larger delayed reinforcer with a progressively increasing hand-open requirement. Results suggest a shift in preference to larger delayed reinforcers and an eventual preference for the hand-open requirement option.

DESCRIPTORS: self-control, impulsivity, physical therapy, delayed reinforcement

“If delay discounting moderates treatment effectiveness, it follows that information about an individual’ s propensity to discount delayed rewards may be quite useful when it comes to choosing intervention components.”

Future implications and utility for TBI:
Effort research
Altruism
Neuroeconomics

Future implications and utility for TBI:
Mindfulness
Acceptance and Commitment Therapy
Progressive delay
Brain plasticity research

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Thanks!