Ghosts of XSS Past, Present and Future

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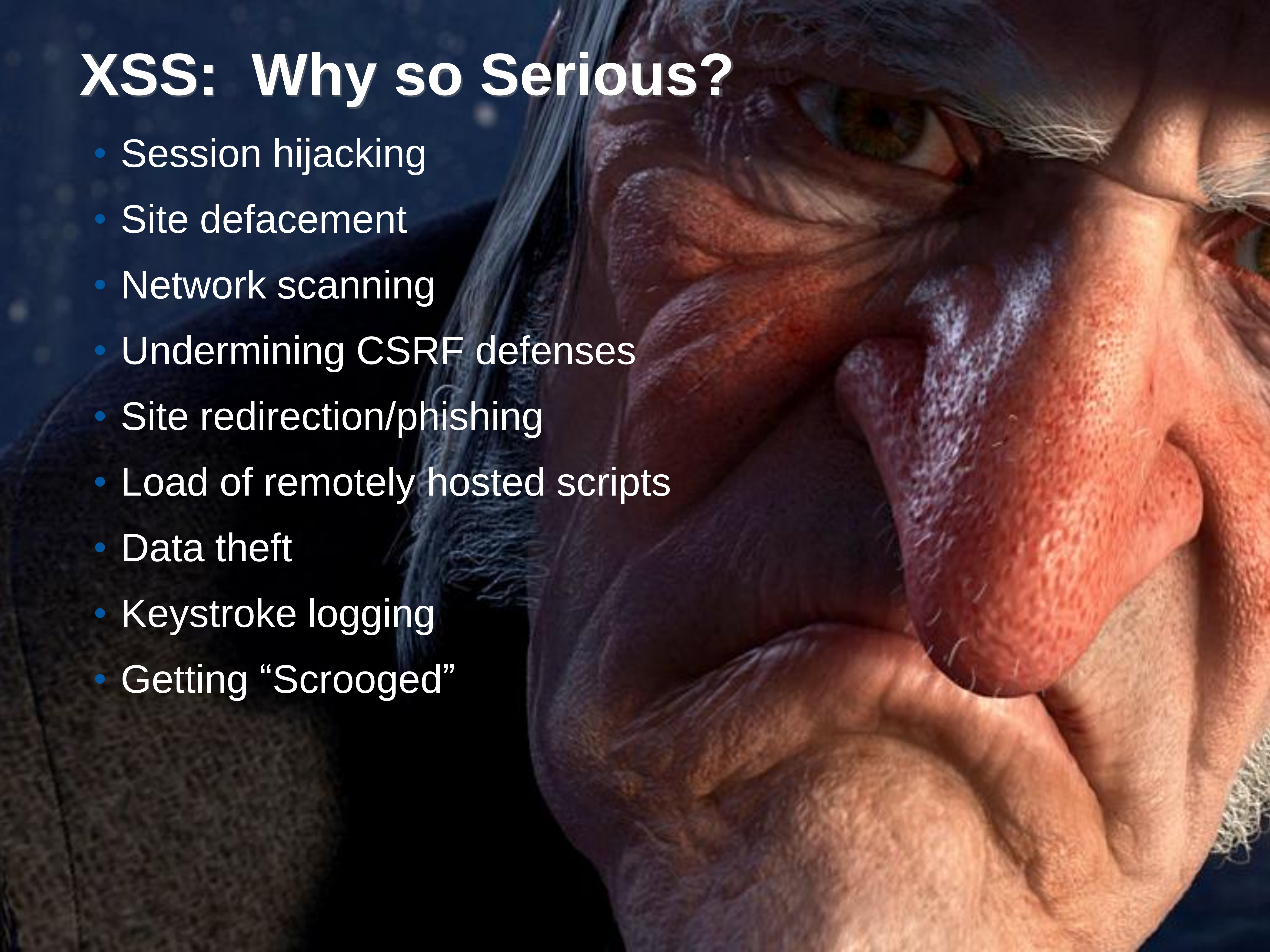
WhiteHat SECURITY

Jim Manico

- VP Security Architecture, WhiteHat Security
- 15 years of web-based, database-driven software development and analysis experience
- Over 7 years as a provider of secure developer training courses for SANS, Aspect Security and others
- OWASP Connections Committee Chair
  - *OWASP Podcast Series Producer/Host*
  - *OWASP Cheat-Sheet Series Manager*



XSS: Why so Serious?

- Session hijacking
- Site defacement
- Network scanning
- Undermining CSRF defenses
- Site redirection/phishing
- Load of remotely hosted scripts
- Data theft
- Keystroke logging
- Getting “Scrooged”

Past XSS Defensive Strategies

- 1990’s style XSS prevention
- Eliminate <, >, &, ", ' characters?
- Eliminate all special characters?
- Disallow user input?
- Global filter?

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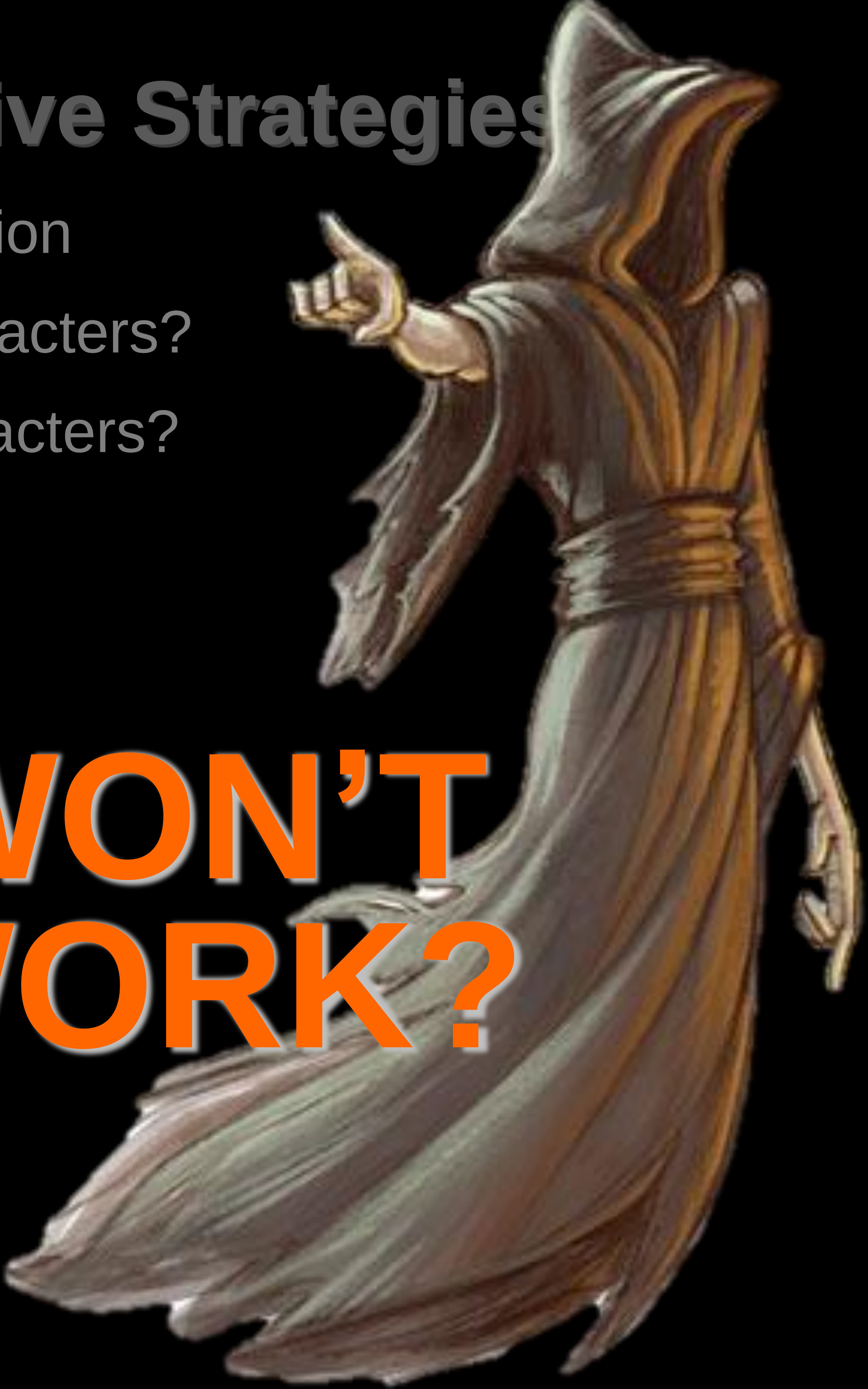
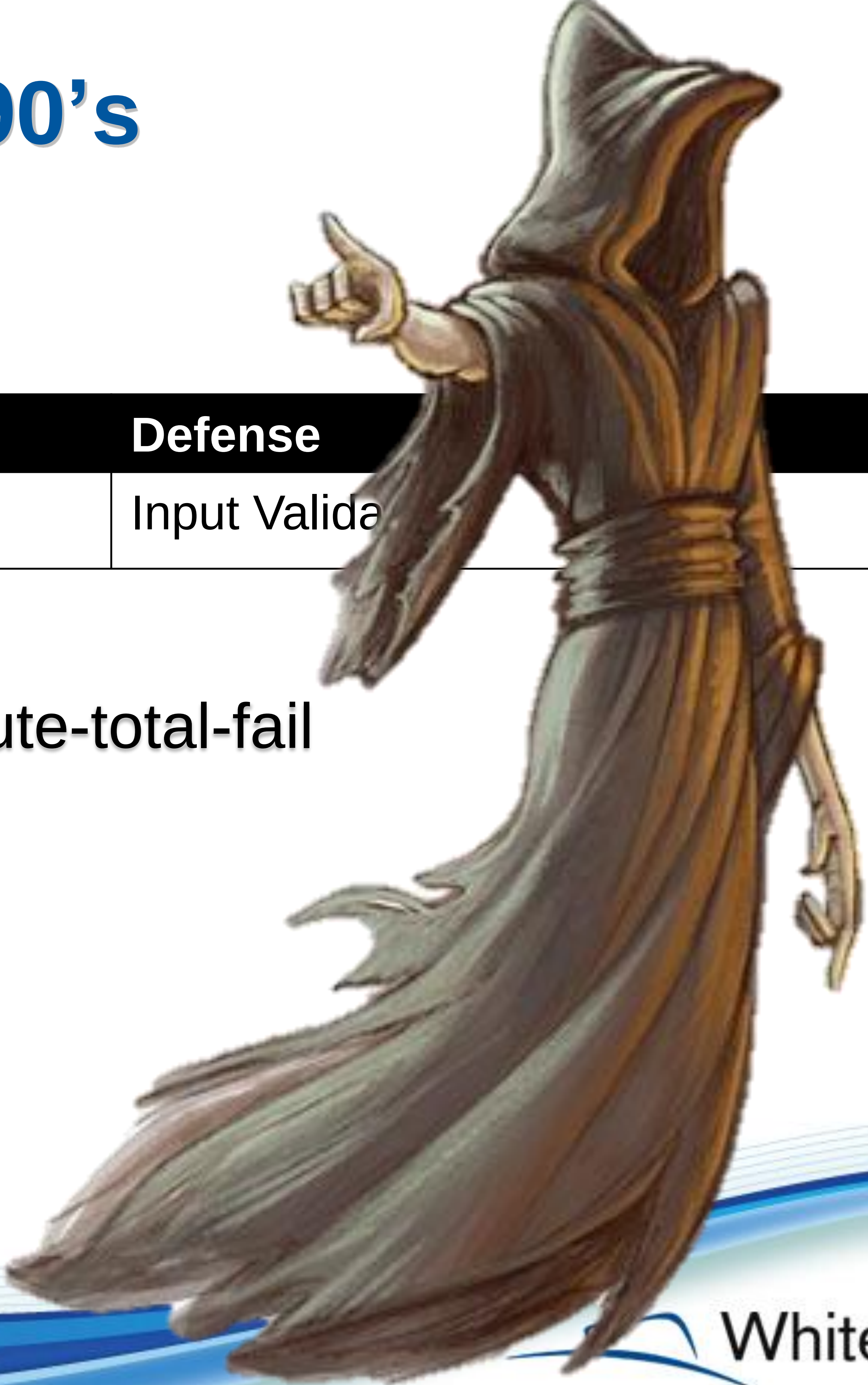
WHY WON’T THIS WORK?



XSS Defense, 1990's

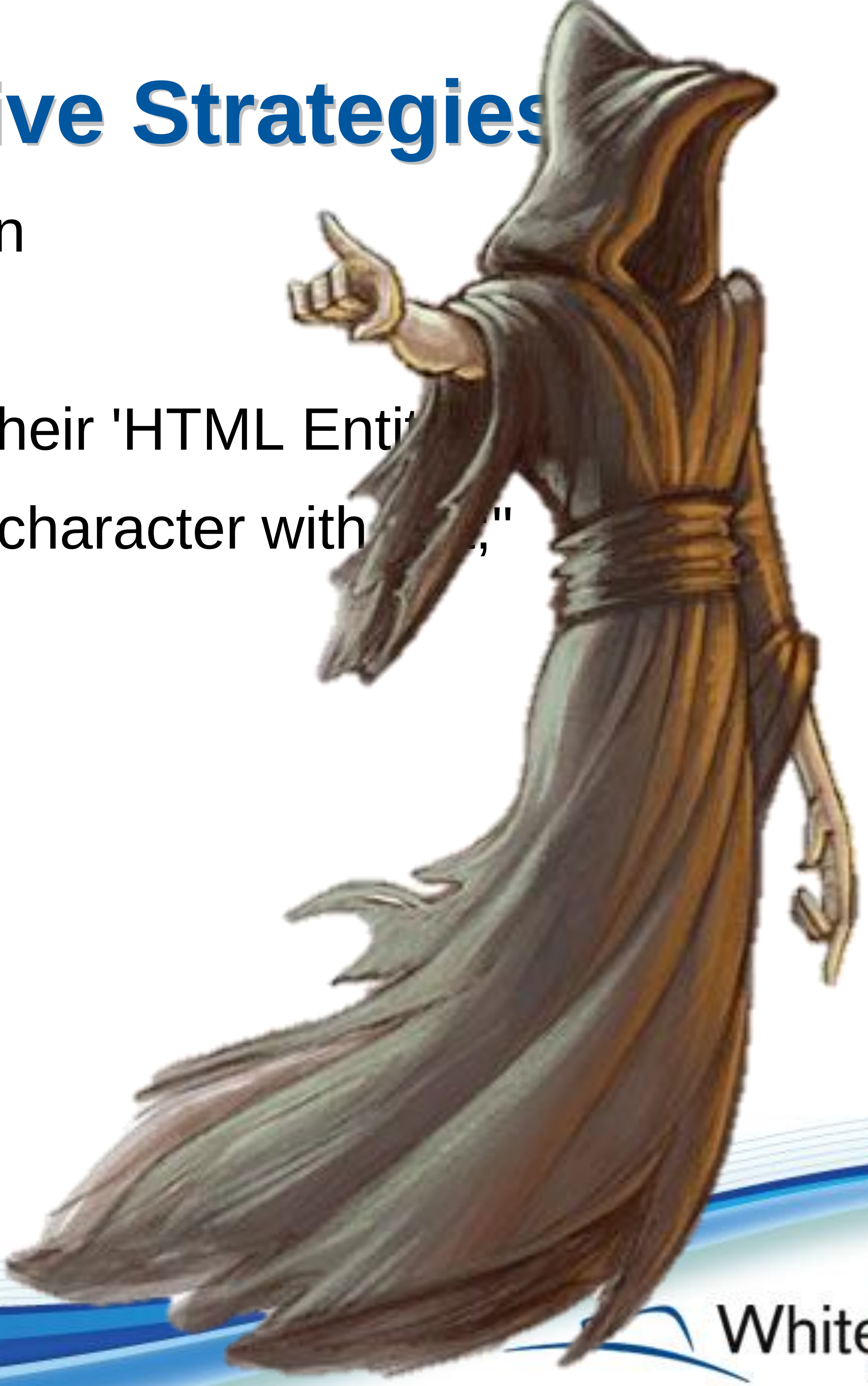
Data Type	Defense
Any Data	Input Valida

#absolute-total-fail



Past XSS Defensive Strategies

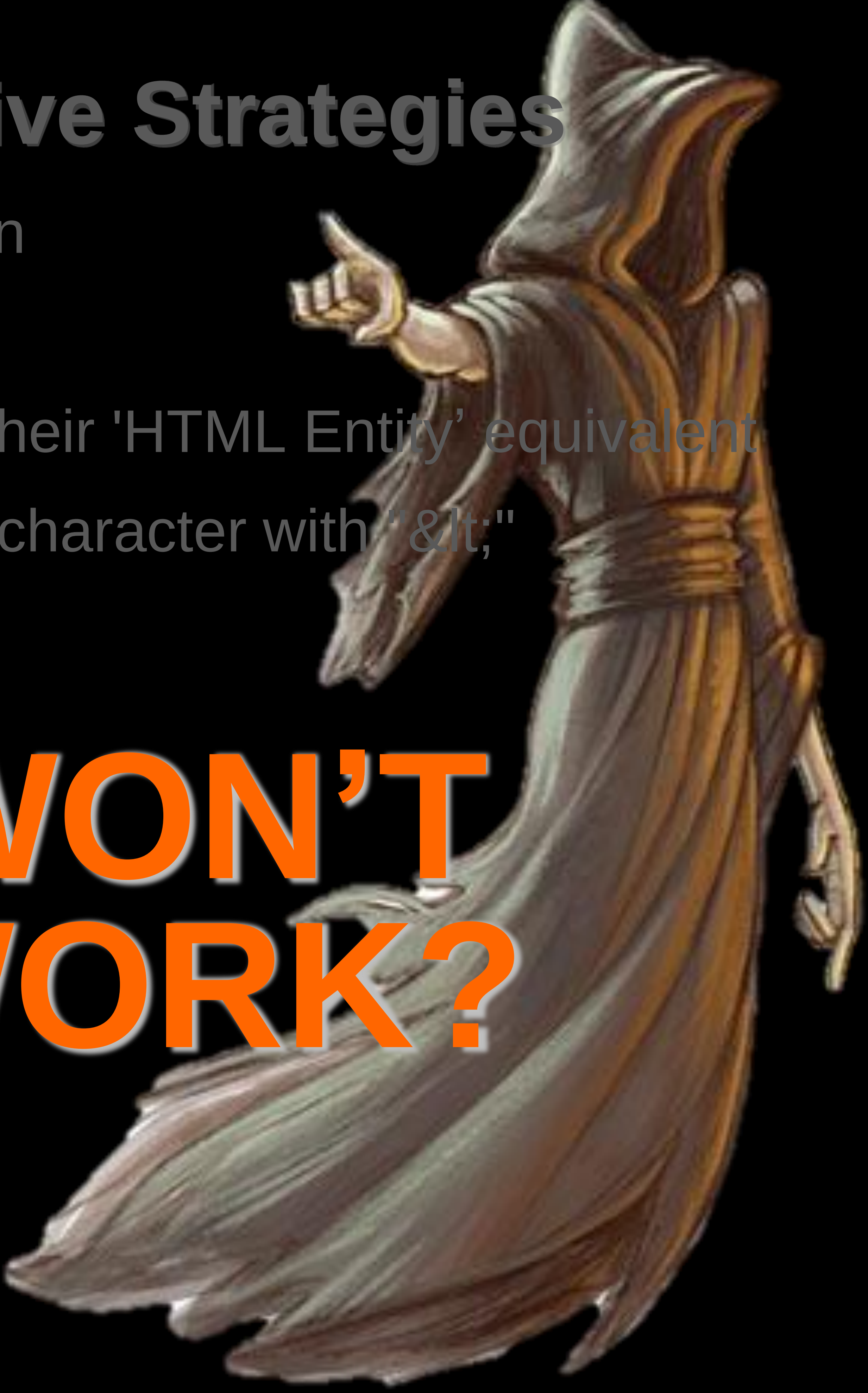
- Y2K style XSS prevention
- HTML Entity Encoding
- Replace characters with their 'HTML Enti
- Example: replace the "<" character with ;"



Past XSS Defensive Strategies

- Y2K style XSS prevention
- HTML Entity Encoding
- Replace characters with their 'HTML Entity' equivalent
- Example: replace the "<" character with "&lt;"

WHY WON'T THIS WORK?



XSS Defense, 2000

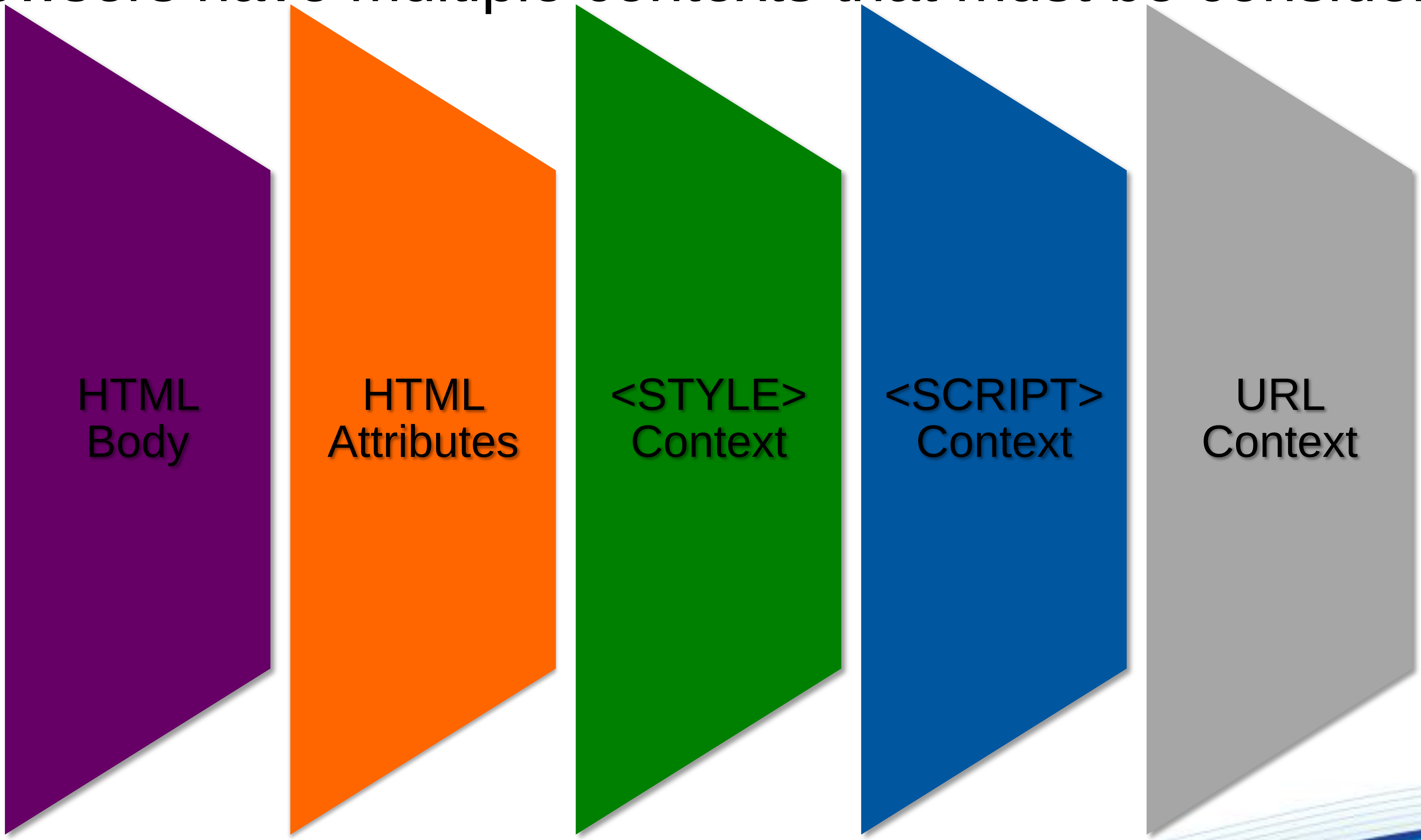
Data Type	Defense
Any Data	HTML Entity Encoding

XSS Defense, 2000

Data Type	Defense
Any Data	HTML Entity Encoding

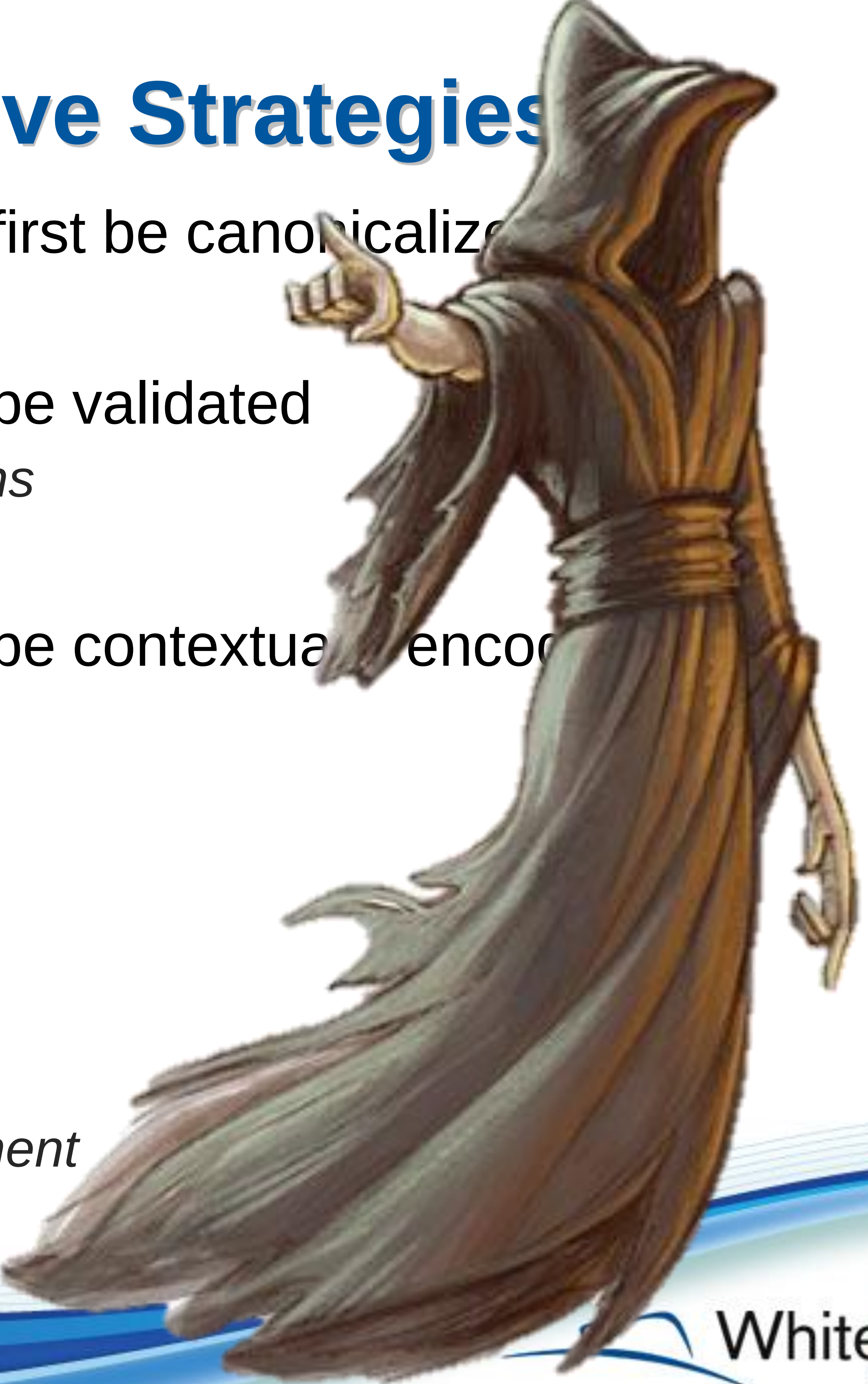
Danger: Multiple Contexts

Browsers have multiple contexts that must be considered!

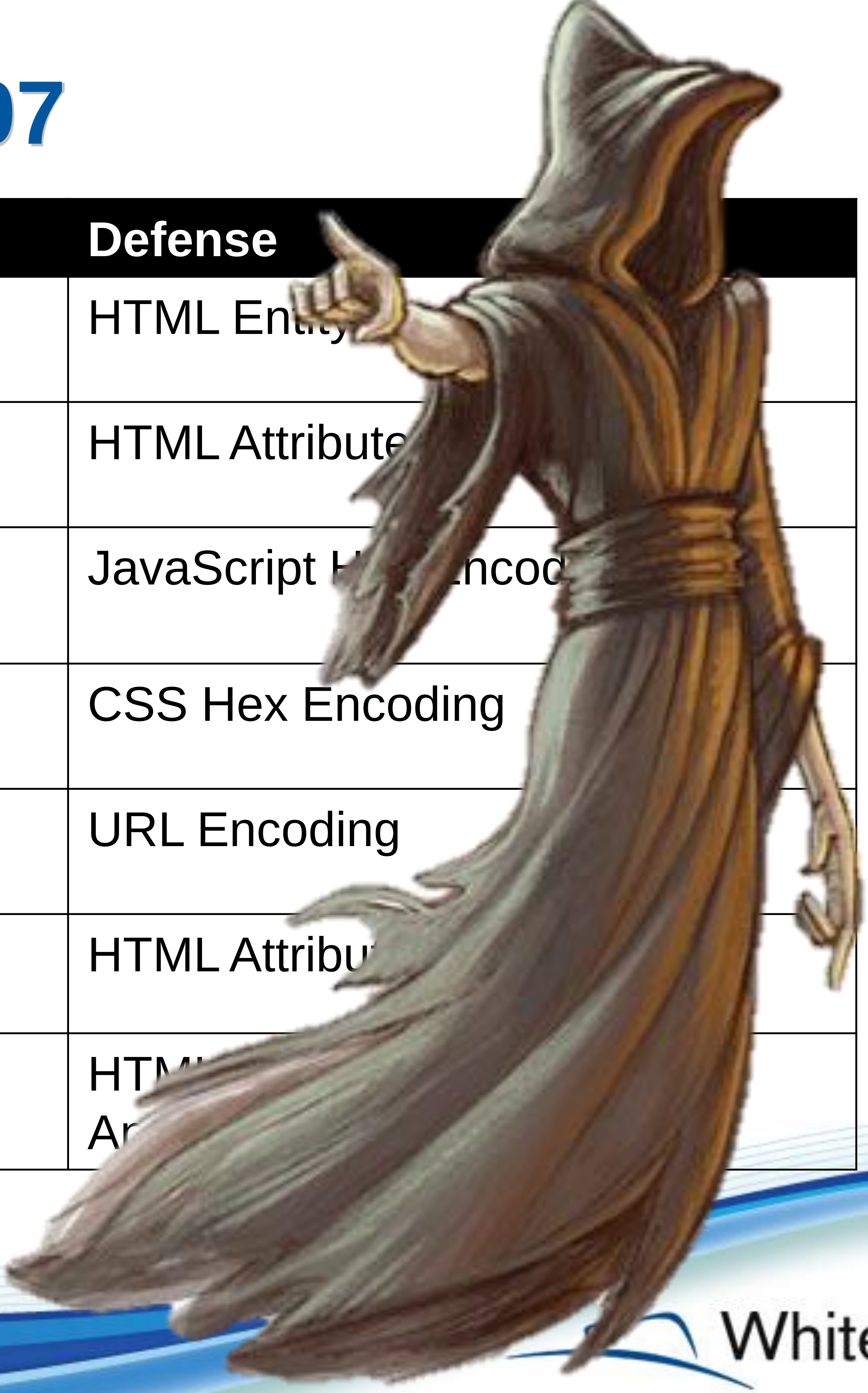


Past XSS Defensive Strategies

1. All untrusted data must first be canonicalize
   - *Reduced to simplest form*
2. All untrusted data must be validated
   - *Positive Regular Expressions*
   - *Blacklist Validation*
3. All untrusted data must be contextua encod
   - *HTML Body*
   - *Quoted HTML Attribute*
   - *Unquoted HTML Attribute*
   - *Untrusted URL*
   - *Untrusted GET parameter*
   - *CSS style value*
   - *JavaScript variable assignment*



XSS Defense, 2007



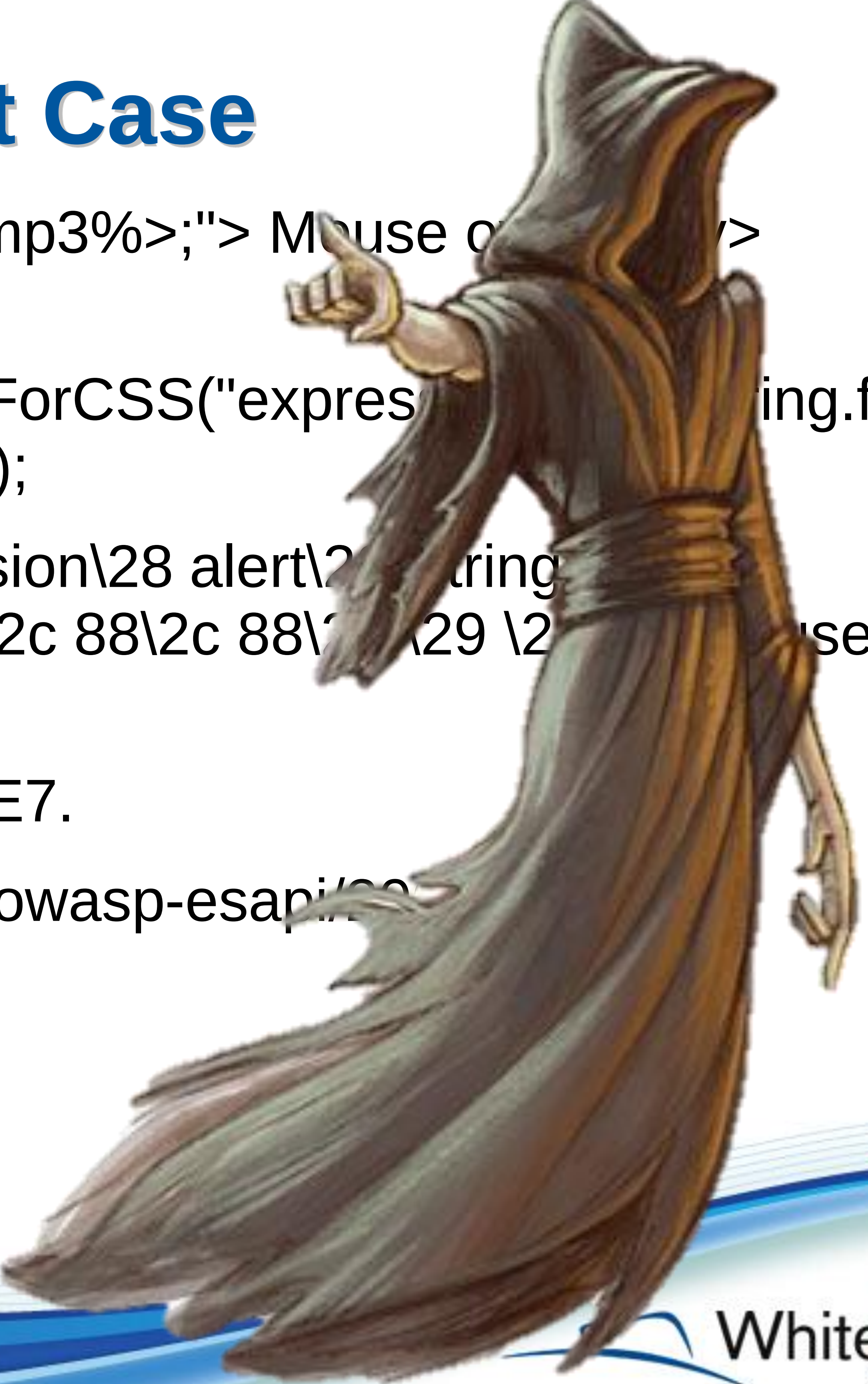
Context	Defense
HTML Body	HTML Ent
HTML Attribute	HTML Attribute
JavaScript variable assignment JavaScript function parameter	JavaScript H ncod
CSS Value	CSS Hex Encoding
GET Parameter	URL Encoding
Untrusted URL	HTML Attribu
Untrusted HTML	HTM Ar

I Got Some

BAD NEWS

CSS Pwnage Test Case

- <div style="width: <%=temp3%>;"> M use o >
- temp3 = ESAPI.encoder().encodeForCSS("expres ing.fromCharCode (88,88,88)))");
- <div style="width: expression\28 alert\2 tring fromCharCode\20 \28 88\2c 88\2c 88\ \29 \2 se over </div>
- Pops in at least IE6 and IE7.
- lists.owasp.org/pipermail/owasp-esapi/20 February/000405.html



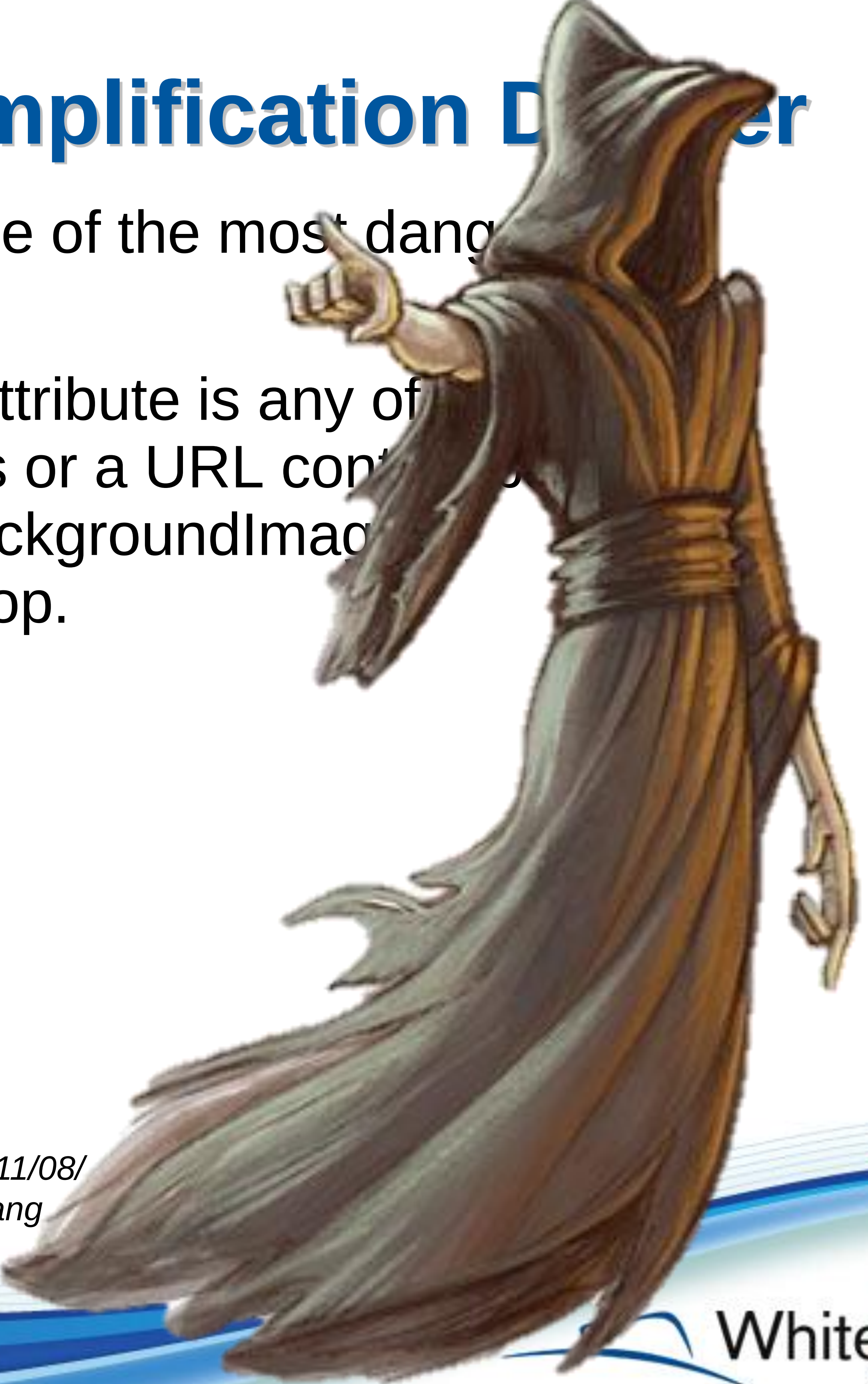
Simplified DOM Based XSS Defense

- 1. Initial loaded page should only be static content.
- 2. Load JSON data via AJAX.
- 3. Only use the following methods to populate the DOM
  - *Node.textContent*
  - *document.createTextNode*
  - *Element.setAttribute*

References: http://www.educatedguesswork.org/2011/08/guest_post_adam_barth_on_three.html and Abe Kang

Dom XSS Oversimplification D er

- Element.setAttribute is one of the mos dang JS methods
- If the first element to setAttribute is any of JavaScript event handlers or a URL con attribute ("src", "href", "backgroundImag "backgound", etc.) then pop.



References: http://www.educatedguesswork.org/2011/08/guest_post_adam_barth_on_three.html and Abe Kang

Best Practice: DOM Based XSS Defense I

- Untrusted data should only be treated as displayable text
- JavaScript encode and delimit untrusted data as quoted strings
- Use document.createElement("…"), element.setAttribute("…","value"), element.appendChild(…), etc. to build dynamic interfaces
- Avoid use of HTML rendering methods
- Understand the dataflow of untrusted data through your JavaScript code. If you do have to use the methods above remember to HTML and then JavaScript encode the untrusted data
- Make sure that any untrusted data passed to eval() methods is delimited with string delimiters and enclosed within a closure or JavaScript encoded to N-levels based on usage and wrapped in a custom function

Best Practice: DOM Based XSS Defense II

- Limit the usage of dynamic untrusted data to right side operations. And be aware of data which may be passed to the application which look like code (eg. location, eval()).
- When URL encoding in DOM be aware of character set issues as the character set in JavaScript DOM is not clearly defined
- Limit access to properties objects when using object[x] access functions
- Don't eval() JSON to convert it to native JavaScript objects. Instead use JSON.toJSON() and JSON.parse()
- Run untrusted script in a sandbox (ECMAScript canopy, HTML 5 frame sandbox, etc)

JavaScript Sandboxing

- Capabilities JavaScript (CAJA) from Google
  - *Applies an advanced security concept, capabilities, to define a version of JavaScript that can be safer than the sandbox*
- JSReg by Gareth Heyes
  - *JavaScript sandbox which converts code using regular expressions*
  - *The goal is to produce safe Javascript from a untrusted source*
- ECMAScript 5
  - *Object.seal(obj)*
    Object.isSealed(obj)
  - *Sealing an object prevents other code from deleting, or changing the descriptors of, any of the object's properties*

JSReg: Protecting JS with JS

- JavaScript re-writing
  - *Parses untrusted HTML and returns trusted HTML*
  - *Utilizes the browser JS engine and regular expressions*
  - *No third-party code*
- **First layer is an iframe** used as a safe throw away box
- **The entire JavaScript objects/properties list was whitelisted** by forcing all methods to use suffix/prefix of "$"
- **Each variable assignment was then localized** using var to force local variables
- Each object was also checked to ensure it **didn’t contain a window reference**

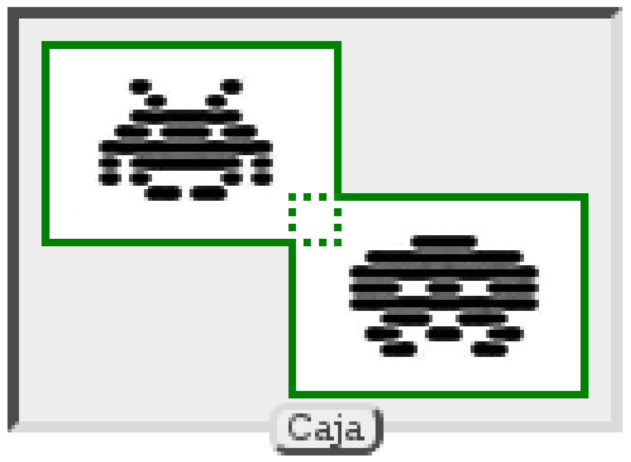
XSS Defense, Today

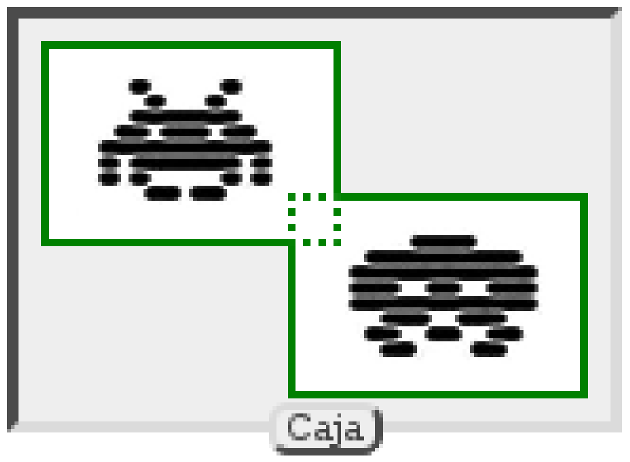
XSS Defense, Today

Data Type	Context	Defense
Numeric, Type safe language	Doesn’t Matter	Cast to Numeric
String	HTML Body	HTML Entity Encode
String	HTML Attribute, quoted	Minimal Attribute Encoding
String	HTML Attribute, unquoted	Maximum Attribute Encoding
String	GET Parameter	URL Encoding
String	Untrusted URL	URL Validation, avoid javascript: URL’s, Attribute encoding, safe URL verification
String	CSS	Strict structural validation, CSS Hex encoding, good design
HTML	HTML Body	HTML Validation (JSoup, AntiSamy, HTML Sanitizer)
Any	DOM	DOM XSS Cheat sheet
Untrusted JavaScript	Any	Sandboxing
JSON	Client parse time	JSON.parse() or json2.js

Google CAJA: Subset of JavaScript

- Caja sanitizes JavaScript into Cajoled JavaScript
- Caja uses multiple sanitization techniques
  - *Caja uses STATIC ANALYSIS when it can*
  - *Caja modifies JavaScript to include additional run-time checks for additional defense*





CAJA workflow

- The web app loads the Caja runtime library which is written in JavaScript
- All un-trusted scripts must be provided as Caja source code to be statically verified and cajoled by the Caja sanitizer
- The sanitizer's output is either included directly in the containing web page or loaded by the Caja runtime engine

Caja Compliant JavaScript

- **A Caja-compliant JavaScript program** is one which
  - *is statically accepted by the Caja sanitizer*
  - *does not provoke Caja-induced failures when run cajoled*

- Such a program should have the same semantics whether run *cajoled* or not

#@$(This

- **Most of Caja's complexity is needed to defend against JavaScript's rules regarding the binding of "this".**
- **JavaScript's rules for binding "this" depends** on whether a function is invoked
  - *by construction*
  - *by method call*
  - *by function call*
  - *or by reflection*
- If a function written to be called in one way is instead called in another way, its **"this" might be rebound to a different object** or even to the global environment.

FUTURE

Context Aware Auto-Escaping

- Context-Sensitive Auto-Sanitization (CSAS) from Google
  - *Runs during the compilation stage of the Google Closure Templates to add proper sanitization and runtime checks to ensure the correct sanitization.*
- Java XML Templates (JXT) from OWASP by Jeff Ichnowski
  - *Fast and secure XHTML-compliant context-aware auto-encoding template language that runs on a model similar to JSP.*
- Apache Velocity Auto-Escaping by Ivan Ristic
  - *Fast and secure XHTML-compliant context-aware auto-encoding template language that runs on a model similar to JSP.*

Auto Escaping Tradeoffs

- Developers need to write highly compliant templates
  - *No "free and loose" coding like JSP*
  - *Requires extra time but increases quality*

- These technologies often do not support complex contexts
  - *Some are not context aware (really really bad)*
  - *Some choose to let developers disable auto-escaping on a case-by-case basis (really bad)*
  - *Some choose to encode wrong (bad)*
  - *Some choose to reject the template (better)*

Content Security Policy

- Externalize all JavaScript within Web pages
  - *No inline script tag*
  - *No inline JavaScript for onclick or other handling events*
  - *Push all JavaScript to formal .js files using event binding*

- Define the policy for your site and whitelist the allowed domains where the externalized JavaScript is located
- Add the X-Content-Security-Policy response header to instruct the browser that CSP is in use
- Will take 3-5 years for wide adoption and support

XSS Defense, Future?

Data Type	Context	Defense
Numeric, Type safe language	Doesn't Matter	Auto Escaping Templates, Content Security Policy, Sandboxing
String	HTML Body	
String	HTML Attribute, quoted	
String	HTML Attribute, unquoted	
String	GET Parameter	
String	Untrusted URL	
String	CSS	
Untrusted JavaScript	Any	
HTML	HTML Body	
Any	DOM	
Untrusted JavaScript	Any	
JSON	Client parse time	JSON.parse()

Thank You

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A BIG THANK YOU TO:
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